NOVEMBER 1961
Vol. 80, No. 11

ELECTRICAL ENGINEERING

Published by American Institute of Electrical Engineers

CONTENTS

Fuel cells and their effects on utilities J. D. FLYNN 828
Although the fuel cell concept is not new, only recently have scientists and engineers returned to it with renewed interest

Marine navigation traffic control system
O. A. KOLODY, F. A. PRAVER 832
A system of navigation for channel, harbor, and bay areas that is independent of weather, darkness, and human error

Static overcurrent tripping device for low-voltage breakers R. L. WINSHIP 837
To overcome the shortcomings of present electromechanical tripping devices, a static semiconductor type has been developed

Speed regulation by digital methods
W. C. SCHMIDT, R. R. POTTS 842
Use of digital techniques in a speed-regulating system permits control accuracies not attainable by other methods

Minimum-resistance coil design
HARRY G. PARKE, URSULA T. PARKE 846
Significant reduction of coil resistance is possible through use of a divided-winding technique

A stitched-wiring process for miniaturized communications electronics J. M. COFFIN, L. B. JOHNSON 849
A recently developed manufacturing process permits economical fabrication of circuits by automatic or semiautomatic methods

Radio influence testing on 70 miles of 345-kv horizontal bundle conductor R. E. GRAHAM, C. R. BOND 854
Radio-influence test results on a 345-kv transmission line to evaluate the selection of line hardware

Correlational and spectral techniques in modern communication and control systems N. D. DIAMANTIDES 860
A new approach to communication and control systems design that is tailored for system-to-signal compatibility

Safe clearances and protection against shocks during live-line work A. ELEK, J. W. SIMPSON 866
The limit of approach to live parts of transmission lines and the physiological effect of the electrostatic field at the tower

DEPARTMENTS

Trends . . . as seen by EE 827
Progress in Technology 873
Plasma Engine for Satellites 873
Two Firms Develop Wire for Superconducting Magnets 875
Development Work Under Way on New Power Sources 875
New Television Tube Has No Horizontal Lines 876
Electrostatic Printing 876
Speed-Up Accomplished in Banking Transactions 877
High-Speed Photographs Document Laser Operation 878
Automatic Road Paver 879

CONTENTS CONTINUED ON PAGE 3A

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We'll show you proof of savings

Conductor side-sway is an important factor in the design of high-voltage transmission lines.

On a conventional 230-kv line with free-swinging suspension strings, conductor sway at the structure necessitates an additional 35 feet of width in the right of way, an additional 10 feet of crossarm width, and an additional 10 feet of structure height. These requirements are correspondingly higher at higher voltages.

If conductors are restrained by V-strings, significant savings can be achieved in right of way, structures, and maintenance - - and electrical performance of the line can also be improved.

If you'd like more detailed information, send for O-B publication number 1503-H, "High Voltage Line Economies With V-string Insulators."

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NOVEMBER 1961
Vol. 80, No. 11

ELECTRICAL ENGINEERING

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CONTENTS (continued)

Letter to the Editor	880
New Library Books	881
Technical Literature	882
Russian Translations	884
AIEE on the Move	886
Cornerstone Box from Old Engineering Building Opened	886
Exposition to be Held with Winter General Meeting	886
1962-63 Fortescue Fellowship Award Made Available	887
Institute Technical Groups Forming	887
Call for Nominations!	888
Future Meetings of Other Societies	889
Calendar of Future Meetings	890
AIEE Section and Student Branch Meetings, 1960-61	892
8th National Symposium on Reliability and Quality Control	894
U. S. Participation Fostered in Global Computer Congress	895
AIEE Fellows Elected	898
Members in the News	900
Obituaries	902
Summaries of AIEE Papers	903
New/Improved Products	8A
Industrial Notes	30A
Product Literature	38A
Engineering Societies Personnel Service, Inc.	44A
Index to Advertisers	48A

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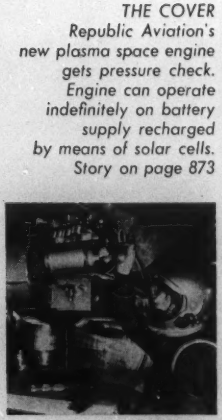
THE COVER
Republic Aviation's new plasma space engine gets pressure check. Engine can operate indefinitely on battery supply recharged by means of solar cells. Story on page 873



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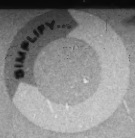
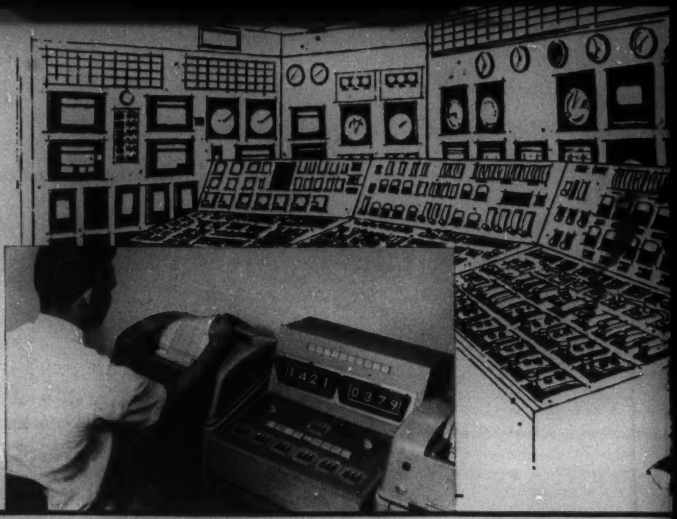
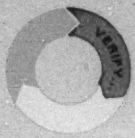


FIRST SIMPLIFY...

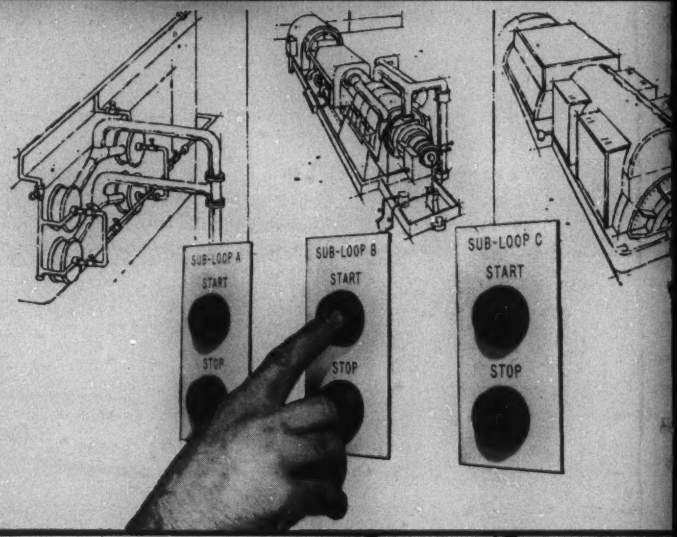
First step to automation is to *simplify* the information now presented by a multitude of multi-record charts, gages, and annunciator lights. The Bailey approach gives the operator data he needs (logged periodically), keeps continuous watch on all variables, makes calculations where required, alarms when trouble threatens. Reliability of recorded data is increased . . . operators can devote full attention to correcting off-normal conditions and improving operations.





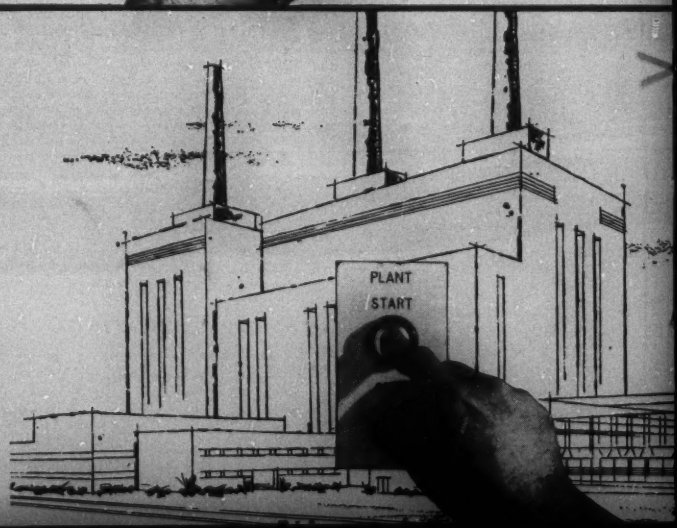
NEXT VERIFY...

Next, verify the practicability of automation by extending supervisory controls, letting equipment perform more operating functions. Automate key systems, one at a time, by push-button controlled sub-loops. This approach smooths the transition to complete automation and improves safety to men and machinery by providing safe, uniform start-up, shut-down, and normal operating procedures.



THEN AUTOMATE

Final steps to automation can then be made at any time with full confidence and proved operational experience. These steps are: 1) to consolidate supervisory controls, conventional controls, and sub-loops for full-range automatic operation once the plant has been placed on the line; and 2) ultimately, to add start-stop control to provide full automation.



THIS ALL FUSE INSTALLATION PROVIDES NEEDED HIGH INTERRUPTING CAPACITY—AND SAVED AN ESTIMATED $20,000

A new electrical system was installed at the Sandusky Foundry and Machine Co., to feed a 1000 KVA annealing furnace and plant feeders and sub-feeders.

The engineers at Universal Marine Construction Co., Sandusky, Ohio who designed and installed the job, estimated the available fault current would be in the neighborhood of 75,000 amperes.

To be sure of obtaining the needed safe and dependable protection BUSS Hi-Cap and FUSETRON dual-element fuses were installed.

DEPENDABLE PROTECTION AT A $20,000 SAVING

Including the cost of fuses and switches, an estimated $20,000 was saved over what it would have cost to use mechanically operated devices with an interrupting rating of only 75,000 amperes.

This BUSS and FUSETRON fuse installation also permitted the electrical system to be co-ordinated, so outages on feeder and sub-feeder circuits can be limited to the circuit on which trouble occurs.

ELECTRICAL SYSTEM NOT DISTURBED WHEN TRANSFORMER CAPACITY WAS INCREASED

Shortly after the original installation, additional transformer capacity was added,—bringing the available fault current to approximately 150,000 amperes.

No change in the main service panels was needed, however, as the 200,000 amp. interrupting capacity of BUSS Hi-Cap fuses is still adequate to assure safe protection.

Neither was a change required in the protection of feeder circuits because FUSETRON fuses have adequate interrupting capacity to safely handle any fault that might occur on them.

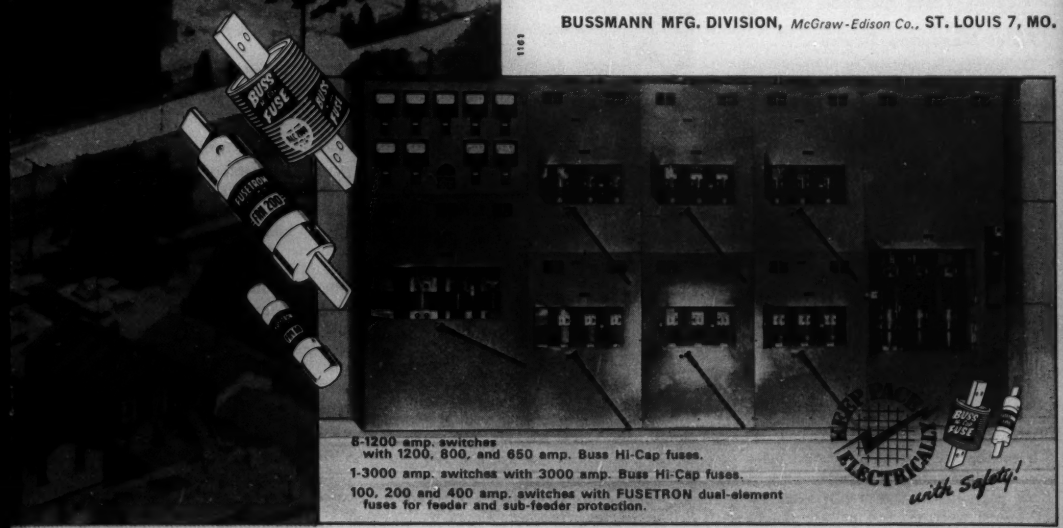
SAFE PROTECTION REMAINS SAFE

After years of inactivity, BUSS Hi-Cap and FUSETRON fuses provide the same safe, accurate protection if called upon to open as they would on the day installed. Dust, fumes, corrosion or age cannot increase the capacity of fuses or lengthen their blowing time.

For more information on how to select the proper fuse, write for the new BUSS booklet . . . *Basic Protection for Electrical Power Systems.*

BUSSMANN MFG. DIVISION, *McGraw-Edison Co.,* **ST. LOUIS 7, MO.**

1103



8-1200 amp. switches with 1200, 800, and 650 amp. Buss Hi-Cap fuses.

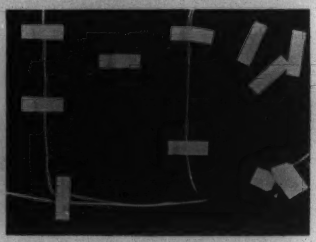
1-3000 amp. switches with 3000 amp. Buss Hi-Cap fuses.

100, 200 and 400 amp. switches with FUSETRON dual-element fuses for feeder and sub-feeder protection.

NEW/IMPROVED PRODUCTS

Wire Harness Holder . . .

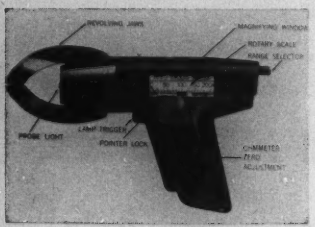
A two-part flexible fastening material now available is useful for holding wiring harnesses in place. Known as Velcro, the material consists of two parts. One part is made of loomed memory nylon hooks; the other is loomed memory



loops or pile. When the two are pressed lightly together, the hooks and loops; engage, creating a substantial holding power. Separation is accomplished by merely pulling the two apart. The hooks temporarily straighten and release the loops before snapping back to their original hook shape. Wiring harnesses can be held in two ways. First, the harness can be mounted on a sheet of Velcro pile and small pieces of Velcro tape are pressed around the wires, as shown in the accompanying illustration. A second technique (see arrow in illustration) is to use Velcro tape made with hooks on one side and loops on the reverse side. Groups of wires are then held by simply wrapping the tape around in any desired direction. *Hartwell Corp., 9035 Venice Blvd., Los Angeles 34, Calif.*

Pistol Measuring Device . . .

Difficulties in measuring current, voltages, resistance and in testing circuits in inaccessible areas may be eliminated wth the Pistolmeter. Revolving jaws at the muzzle end of the device permit their insertion into cramped gutters and cable



boxes at any convenient angle. The trigger-operated probe light at the meter's end insures safe, easy handling. The meter has four current ranges—0-15/60/200/600 amperes; two voltage ranges—0-150/600 volts; and two ohmmeter ranges —0-500/5000 ohms. *Federal Pacific Electric Co., 50 Paris St., Newark, N. J.*

Power Control . . .

A new high-power, lightweight silicon-controlled-rectifier power control provides stepless control of power from zero level to a full 70 kw and power output is controlled automatically or remotely by milliwatt d-c signal. All components are designed and installed for easy access. *Lindberg Engineering Co., 2450 W. Hubbard St., Chicago 12, Ill.*

Engine-Generator . . .

Weighing only 40 pounds, a new model C 869-3T engine-generator set is rated at 300 watts, 115 volts, 60 cycles, single-phase. The set is designed as an alternator to reduce the number of moving parts. Its stationary winding, for example, eliminates the need for brushes. The 2-cycle, 1-cylinder Clinton gasoline engine is lubricated by a pressure vapor oil system. The engine is rated at 3600 rpm and has an adjustable pneumatic-type governor. *AGA Corp. of America, P. O. Box 447, S. Plainfield, N. J.*

Cable Adapter . . .

Flat conductor cable can be interconnected with conventional round wire through use of a new adapter device. The unit simplifies the introduction of flat cable to existing electrical and electronic equipment wiring systems. It is used to

terminate flat cable runs at conventional terminal boards or strips, and facilitates flat cable runs under rugs, tile, in chassis, along walls where the ultimate termination is to round wire. *Thomas and Betts Co., 36 Butler St., Elizabeth, N. J.*

Power-Line Monitor . . .

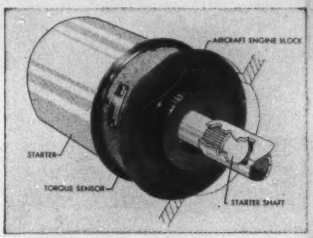
The new WV-120A power-line monitor responds continuously to fluctuations and changes in power-line voltage. The instrument has an expanded scale from 100 to 140 volts for easy reading. A moving-vane type of meter indicates true rms values even when line voltage is not a pure sine wave. Accuracy of readings at 120 volts is ±2 per cent; at 100 and 140 volts, ±3 per cent. *Radio Corp. of America, Electron Tube Div., Distributor Products Dept., Harrison, N. J.*

Electronic Alternator

Development of an all-electronic alternator system to replace the d-c generator in automobiles has been announced. The system is designed to never require adjustment and weighs only one-third as much and costs no more than an equivalent d-c generator. The system, using transistors and diodes throughout, consists of an alternator, a permanently sealed voltage regulator, and an isolation diode. It is claimed that the sealed regulator will last well beyond the life of the automobile. The alternator system is rated at 600 watts of power and is equipped with permanently sealed and lubricated ball bearings. *Motorola Inc., 9401 W. Grand Ave., Franklin Park, Ill.*

Coaxial Torque Sensor . . .

Direct torque measurement of starters, pumps, gear boxes, turbines, and other



high-speed rotating machinery is now possible with a new device just made available. The model 2302 coaxial torque sensor measures torque by restraining the case of the test device. This provides true dynamic torque with excellent frequency response by eliminating the need for in-line torque sensors which change the rotating inertia of the system being tested. *Lebow Associates, 14857 W. Eleven Mile Rd., Oak Park 37, Mich.*

Frequency Changer

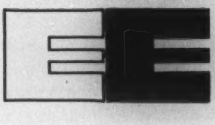
Frequency stability of ±0.25 per cent over maximum line and load change is claimed for this 400-cycle sinewave frequency changer. The solid-state 100 va converter is packaged for bench or rack-mounted applications. Regulation of the adjustable 105- to 130-volt single-phase output is quoted as ±1 per cent from full load or over 105- to 130-volt line change. Input is 105 to 130 volt, 47 to 1000 cps, 2.5 amperes maximum. *Magnetic Research Corp., 3160 W. El Segundo Blvd., Hawthorne, Calif.*

Direct-Current Control . . .

Isolated control and metering of direct-current values to 200,000 amperes and

(Continued on page 21A)

Trends...as seen by



Two new research institutions are planned by the Swedish Academy of Engineering Sciences for Gothenburg and Lund, similar to those established in Stockholm in 1943 and 1950. The capital is to be provided by Swedish industrial companies.

***Research and development** performed by private industrial firms in 1960 amounted to $10.5 billion. This was a 10 per cent increase over the $9.6 billion spent in 1959. This was reported by the National Science Foundation.*

General Telephone & Electronics Corp. has announced the installation of the Atlas intercontinental ballistic missile intersite communications system at Francis E. Warren Air Force base near Cheyenne, Wyo. It is now undergoing acceptance testing.

***Receipt of a $211,150 contract** is announced by General Electric's* Tempo *to establish an information center on the subject of high-altitude nuclear effects, for the use of government, industrial, and academic workers. Contract was awarded by the Defense Atomic Support Agency.*

Under a multimillion dollar international agreement, RCA and Compagnie des Machines Bull, Paris, the former will sell to the French firm a minimum of 50 and a maximum of 100 data-processing systems. Shipments are to begin next July and to be completed in 1964.

***A joint organization has been formed** by Minneapolis-Honeywell Regulator Co. and British Aircraft Corp. to develop, manufacture, and market inertial guidance systems for aircraft and missiles in Europe. Headquarters will be in Paris, France.*

Continental Electronics Mfg. Co. has received a $3 million contract to design a multimegawatt radar transmitter for the Army's tactical Nike-Zeus antimissile system.

***Advantages to be gained from the use of solar energy units** to produce power from the sun in the less well-developed countries have been emphasized at the U.N. Conference on New Sources of Energy in its Rome meeting. Speakers from India, Nigeria, and Indonesia said that conditions in their countries would permit the operation of solar equipment for 2,000-3,000 hours per year.*

***After years of research and development,** electronic business machines manufacturers are expected to reap the benefits of their undertakings, according to the* Value Line Investment Survey. *The opinion is based on increasing volume of orders from two sources: the Armed Forces and commercial customers. Most manufacturers now hold large order backlogs.*

The Bureau of Naval Weapons has awarded two contracts amounting to nearly $1 million to Maxson Electronics Corp. for the production of antisubmarine detection devices.

***Burroughs Corp. has announced its entry into the punched-card electronic computer business,** thus putting the company into competition for the largest single bloc of the billion-dollar a year market.*

A trend toward communication and command control systems research over component reliability in electronics is the most significant finding in a recent poll conducted by the Department of Defense.

***The color television industry is expected to reach a going rate of $200 million** in 1962, according to RCA president J. L. Burns. Looking further to 1970, color can be seen rising to the status of a $4.3 billion industry, including sales, servicing, and broadcast revenue.*

Investor-owned electric utility companies in the United States plan to spend about $8 billion for new electric power transmission facilities through 1970, according to D. C. Luce, president of Public Service Electric & Gas Co.

***Seventy-three scientists and engineers from 20 countries,** including the United States, have registered for the fall term of an international "atoms for peace" training and research program at the Argonne National Laboratory. Since 1955 this training has been attended by more than 700 scientists and engineers from nearly 50 countries.*

A 3-year study by the Lockheed-Georgia Co. to develop nonmetallic tooling for high-temperature applications has been completed. The work was performed under a $192,000 Air Force contract and covered development of materials and tooling techniques for cast refractory or ceramic draw dies.

J. D. FLYNN

Fuel cells and their effects on utilities

Fuel cells will become practical initially in watt sizes, then in kilowatt and in megawatt sizes. As their development advances into the kilowatt range, they will stimulate brisk competition among the oil industry and electric and gas utilities for the opportunities of being the "single energy" source. When the megawatt size is reached, they will favor electric utilities over other energy suppliers

Although the basic concept of fuel cells is not new, only in the past decade or two have scientists and engineers returned to it with renewed interest. This interest has resulted in part from the enormous rate at which we are depleting our fossil fuels and in part from the tantalizingly high operating efficiency promised by fuel cells.

Over 60 governmental and industrial fuel cell projects are known and it is estimated that more than $28 million per year is being spent on their research and development.[1] The goal in mind is that some time in the future this might be developed as a cheap and compact successor to power plants ranging in size from the internal combustion engine all the way up to a power plant generating station.

This diligent research and development work has produced an almost countless number of different types of cells capable of operating on every conceivable fuel from a decomposing compost heap or sea water to sodium and mercury. The laboratory devices developed range in size from milliwatts to kilowatts. The largest built to date is probably the Allis-Chalmers tractor. The largest planned will power a submarine in 1963, if U.S. Navy predictions come true.

Perhaps the greatest role of kva-sized fuel cells will be that of powering mobile equipment rather than producing "homemade" electricity.

All of the popular direct conversion of energy schemes under investigation suffer in varying degree from thermodynamic efficiency limitations imposed by the Carnot principle; not so with fuel cells. They are not a heat engine and do not have the Carnot limitation. Therein lies their chief appeal, although they do possess other sometimes equally important advantages, such as

1. Lack of moving parts.
2. Silent operation.
3. Efficiency that is independent of the size of the cell over a wide range of power outputs.
4. Convenience in scaling power systems up or down.
5. Fewer maintenance and reliability problems, because there are no moving parts.
6. Ease of tapping for supplying a variety of loads.
7. Relatively high energy per unit weight.
8. A high specific power output, particularly with small-size devices.

They are not without some disadvantages:

1. There is a tendency for efficiency to be highest at light load and to drop off with increasing load.
2. There is a voltage drop attendant with increased current output.
3. Materials do not exist today for electrodes and electrolytes which are at once resistant to high-temperature corrosion and are highly conductive, yet low in cost.
4. Direct current is produced, but the electrical industry is based predominantly on alternating current.

It will probably be desirable to invert d-c to a-c for residential use. The possibility is present that all heating and purely resistive loads can be operated on d-c and all frequency-sensitive loads on a-c. This will depend on the economics of a double wiring system versus a full capacity inverter.

All large-scale generation will most likely be inverted to a-c.

AN ENIGMA TO ELECTRIC UTILITIES

Fuel cells present both a promise and a threat to the electric utilities. Their remarkable efficiencies promise to lower production costs of electricity. But since they are efficient in small sizes as well as large, potentially they can put each home owner in the power plant business.

Efficiency is not their only contribution to success-

Full text of conference paper 61-1092, presented at the AIEE Fall General Meeting, Detroit, Mich., Oct. 15-20, 1961, at a session sponsored by the AIEE Power Generation Committee.

J. D. Flynn is with the Cincinnati Gas & Electric Company, Cincinnati, Ohio.

ful large-scale power generation. Their simplicity of design and manufacture certainly indicates that their capital cost will be considerably less than the complicated turbogenerators of today. The lack of moving parts and simplicity of control should reduce both operating and maintenance expenses. Their disadvantage is obvious. They produce d-c power at relatively low voltage. Since our power systems are based on a-c power, fuel cells face the economic disadvantage of the cost of conversion equipment. However, this cost is being steadily reduced by the advances in the technology of solid-state inversion of d-c to a-c.

As a bulk power producer, the fuel cell must be of the type which can use one of the cheap fossil fuels. For most utilities this would be coal. Thus far, however, attempts to use coal or coke directly in the fuel cell have been disappointing. It is more promising to gasify these fuels. They require high activation energy before they will react at the fuel electrode. No catalyst has yet been discovered which would cause them to react at low or ambient temperatures. In order for fossil fuels to react it is necessary to use higher-temperature cells. Therefore, aqueous electrolytes are not feasible, because to keep them invariant throughout the operation prohibitively high pressures are developed. This leads to the use of molten-salt electrolytes, which can stand high temperatures with reasonably low pressures.

Before reaching the stage of a primary electric power generator, the hydrox cell may provide an economic method of utilizing off-peak power. (The hydrox cell is essentially any low- or intermediate-temperature hydrogen–oxygen cell.) During the night, excess energy could be rectified and used to electrolyze water into hydrogen and oxygen gas. The gases would be stored until peak hours, when they would be fed into batteries of hydrox cells, producing d-c power. After conversion to a-c, this power could be used for peaking.

In this respect, nuclear plants have such an exceedingly high capital cost that they can best be utilized by running them full blast regardless of hourly power demands. Their off-peak power could be used to store energy by making hydrogen, which could be delivered wherever needed to run fuel cells.[2]

The combination of nuclear reactors and fuel cells offers a number of interesting possibilities aside from off-peak power applications. There are two ways in which nuclear energy might be used in conjunction with regenerative-type fuel cells. In one case it is the heat output and in the other case it is the radiation energy which could be used to split the product of the over-all fuel cell reaction back into the original fuel and oxygen gases.[3]

Earlier it was pointed out that because the fuel cell efficiency was not dependent upon size it might be termed a foe. However, this aspect of fuel cell characteristics might be very helpful to electric utilities.

A large portion of the cost of a kilowatt delivered to a customer is in transmission and distribution. Electric utilities have been forced to locate power plants remotely from the loads for several reasons; among them are noise, exhaust gases, and fly ash. The reason they have been concentrating generating equipment in such large blocks of power is that the efficiency of a turbogenerator goes up with increased size. This condition is not true with fuel cells. They present the possibility of having more and smaller-capacity generating stations which could be located closer to load centers. They would not be objectionable even in a neighborhood location since they have no moving parts to cause noise or vibration and they exhaust no offending gases. The hydrogen–oxygen cell exhausts only water and the carbox cells exhaust only carbon dioxide and water, neither of which are objectionable.

Our coal supplies are being depleted at a tremendous rate. The unfavorable economics of mining much of our coal reserves point toward the possibility of not being able to mine economically more than 50% of what is in the ground. These predictions confirm the inevitability of increasing costs in the generation of electric power. Fuel cells may be one method of holding fuel costs down while at the same time extending the lifetime of fossil fuels.[4]

While foreseeable improvements in the steam plant may cut ⅓ mill from fuel cost, the fuel cell may reduce these costs by as much as 1¾ mills. With the fuel cell used as a base load generator, this could mean per annum savings of hundreds of millions of dollars to the electrical industry.[5]

Fuel cells will permit coal to remain competitive with nuclear power on the basis of fuel costs over a much longer period of time than would be the case for a conventional steam plant.[6]

Fuel cells should be able to reduce fuel costs (high efficiency), capital investment (ease of manufacture and simplicity of design), distribution costs (efficiency not dependent on size), maintenance costs (lack of moving parts), and operating expense (simplicity of operation).

But with an energy potential of the economically recoverable nuclear fuels of over 20 times the corresponding potential of the fossil fuel reserves, it appears that some combination of nuclear energy and fuel cell also has a future.

BRIGHT PROSPECTS TO GAS UTILITIES

The fuel cell could be a major factor not only in the over-all energy system, but also in the future utilization of gas. Gas industry interests in the fuel cell centers around the fact that some units under intensive study and development can use natural-gas components (methane or ethane) or other hydrocarbon fuel gases.[7]

To the gas industry, development of efficient and economical fuel cells, using natural or manufactured gas as a fuel and air as an oxidant, should open up

an entire new era of energy production and utilization. It may be possible that natural-gas fuel cells will eventually find many industrial uses. They also might be used for residential purposes.[8]

Fuel cells using gaseous fuels seem to be the most promising; thus an intimate link between the gas industry and the fuel cell industry seems inevitable. Solid fuels are seen as creating many operating problems in fuel cell operation and they have inherently lower efficiencies.

When natural gas is looked upon as energy rather than as the usual convenient fuel, some interesting cost comparisons can be made. In many parts of this country, a unit of energy in the form of natural gas costs the consumer only $\frac{1}{6}$ to $\frac{1}{8}$ as much as an equal amount of electric energy.[9] But nearly 18 times as much plant investment is required to provide a consumer this same amount of energy electrically. It costs a tenth as much just to distribute energy in the form of natural gas as it does to distribute energy in the form of electricity.

There is good reason for the gas industry to be very much interested in the development of a natural-gas fuel cell.

Coal for direct use in a central-station fuel cell seems ruled out for the near future. Coal is simply too inert, and it contains undesirable elements. Residual oils resemble coal in being ill-suited for direct use in a fuel cell. Natural gas (methane) is the other fossil fuel cheap enough for use in central-station cells. Though extremely inert, it can at least be introduced directly into a cell because it is a gas, and gases can be made to react at the so-called gaseous diffusion electrodes.

The over-all reaction of a natural gas cell is $CH_4 + 2O_2 = CO_2 + 2H_2O$. Most cells would probably operate at a high enough temperature to produce steam as a useful by-product.

Neglecting this by-product and assuming that the heat generated by the cell was sufficient to keep it at operating temperature, Dr. Liebhafsky of the General Electric Research Laboratory has made the following estimate of minimum fuel costs:

If the gas is assumed to cost 20 cents per thousand cubic feet and has an energy value of 1,040 Btu per cubic foot, and assuming the fuel cell operates with an efficiency of 70 per cent, the maximum fuel cost of electricity is $20/(1.04 \times 10^3 \times 10^3) \times 1/(2.930 \times 10^{-4}) \times 1/(0.7) = 0.1$ cent per kw-hr, with 2.930×10^{-4} being the conversion factor from Btu to kilowatt-hours. This fuel cost shows that a central-station natural-gas fuel cell is worth investigating. Based on what is presently known, the fuel cell most likely to succeed in generating electricity competitively with present central stations will use natural gas (perhaps with other gases added to make it more reactive), will operate at about 500 C, and will have molten carbonates as the electrolyte and a cathode containing silver.[10]

Individual home power packs face the penalty of a load diversity factor. Sherman Knapp, president of Edison Electric Institute, recently stated that the total generating capacity provided by central station generation is only a fraction of the total capacity which would have to be provided by all the "little black boxes." Then, too, a high-temperature fuel cell cannot function very well in an "on–off," low load factor application.

This suggests use of an energy storage device which would create a high load factor demand on the fuel cell. Ordinary storage batteries could be used, for example.

Dr. C. G. von Fredersdorff, senior chemist, Institute of Gas Technology, has made an excellent economic study of a domestic fuel-cell system.[11] Using admittedly optimistic assumptions he reports that a 10-year payout is possible if investment costs are no higher than $300 per kilowatt.

The Institute of Gas Technology is currently conducting research on two types of methane fuel cells. The first is a high-temperature cell in which methane reacts in the presence of steam. The second depends on a miniature re-former, so that the cell itself uses hydrogen fuel.

The development of a practical natural gas cell is, of course, most desirable. However, the development of cells operating on hydrogen–carbon monoxide mixtures or process hydrogen may be almost as desirable. It may be feasible to break down methane into these gases and distribute them from centrally located gas installations.

To a combination electric and gas utility, fuel cells hold a possibility of smoothing out the peaks in the loads. The peak loads for an electric utility occur both in the winter and in the summer months. The gas load is distinctly heavier in winter and much lighter in summer. Thus fuel cells afford the possibility of using gas in the summertime to make electricity when there is a demand for electricity but not for gas.

For smaller than central station generators, the gas industry may face competition with the oil industry. Since 1956, the Esso Engineering and Research Company of Linden, N. J., has been building experimental fuel cells and exploring the possibility of a "home power package" which would get its fuel from the heating oil tank to make electricity for lights and appliances. They have conducted tentative surveys to determine how such an oil-burning heat-and-light plant would hit the householder's pocketbook. Esso estimates that it might reduce the total energy cost of a hypothetical 6-room New Jersey house from $380 a year to $125.[12]

"It will take a lot more work to make such a system practical," said Dr. Richard W. Sage, head of Esso Research. "There is no theoretical reason why it can't be done, and recent research by various groups encourages our belief that such savings are

by no means 'blue sky' speculations. Such a home power plant is no more fantastic than the atomic submarine seemed to be a few years ago."

CONCLUSIONS

The current interest in fuel cell development, if maintained, makes it likely that fuel cells will serve as power sources in special applications within the next 5 years. Initially they probably will be restricted to uses where excellence of fuel efficiency, silence, freedom from fumes, and simplicity of design and operation are important requirements.

As the technology of fuel cells advances, they may be used first in off-peak generator facilities to produce hydrogen and oxygen, which can be stored, transported, and utilized at will in fuel cells. They may then be used to supply low-voltage constant loads for such electrochemical processes as plating, water purification, galvanizing, electrolytic cleaning, and electrolytic refining of metals.

Early applications may also find them supplying electricity to places too remote for power lines or gas mains. Here they would be supplied with energy in the form of bottled gas or a tank of oil. One distinct advantage of the fuel cell is that it is just as efficient in small sizes as in large ones. With all other types of power, the bigger the plant the better the fuel economy. This gives the fuel cell a special opportunity in small stationary power plants; perhaps for emergency units in hospitals, or in small factories, motels, and farms.

Indications are that it may be attractive in the future for the gas industry to become the prime energy supplier for several types of fuel cell applications. Recent developments in the fuel cell field appear to justify the conclusions that this prospect is technically feasible.[7] The big question is whether it will be economically feasible.

A successful reversible fuel cell will be a welcome energy-storage mechanism to complement more spectacular devices such as nuclear reactors, fusion devices, and solar energy converters. As fossil-fuel reserves diminish, the high efficiency of the fuel cell will become still more attractive.

It is entirely conceivable that there will be a period in our future when central power stations will give way to individual fuel cells in every home. At a later period, when fossil fuels have become so scarce that they can no longer be used for fuels, we may revert again to a central distribution, possibly using a combination nuclear reactor fuel cell generating plant.

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Instrument Measures Turbine Blades

This automatic device at the Allis Chalmers West Allis (Wis.) works is for the precise measurement of steam turbine exhaust blade profiles. The measuring concept is based on the rectangular co-ordinate system. An unlimited number of rectangular co-ordinates of points representing the design blade profile can be punched into 8-column paper or input tape.

The tape is fed into the control unit and supplies the positioning units with nominal movements. The positioning units then move the measuring probes to the specified locations. When the probes make contact with the profile, a stylus in the recording unit indicates any deviation of the point from the nominal. Each station along the length of the blade profile is measured completely automatically. Over-all accuracies to within ± 0.003 inch are readily attainable.

O. A. KOLODY and G. A. PRAVER

Marine navigation traffic control system

A system of marine navigation for channel, harbor, and bay areas has been developed that is independent of weather and darkness, and of human error. Two transmitters, operating on different frequencies, feed two cable loops located in the bed of the channel. Signals picked up and displayed on visual indicators guide watercraft along a 2-way traffic lane established by the cable loops.

Despite the progress in the field of communications in the last few decades, little advancement has been made in marine navigation. Present methods rely upon complex systems of buoys and markers which have become virtually impossible for a layman to understand and are even difficult for an experienced seaman to follow.

The only real improvement in commercial navigation has been the application of radio beacons. Basically, the system consists of two radio beams that a ship receives, which thus fixes its position. Several such systems exist which vary in minor details from this principle. The system is adequate for oceanic navigation, but is of no avail in channels, rivers, bays, harbors, etc. These navigation routes are at present outlined by buoys and markers which cannot be seen after nightfall or during periods of bad weather. For this reason the buoys are provided with audible signals, such as bells, whistles, and horns. Activated only by water and wind, these become nonfunctional in calm weather, and are inaudible in stormy weather.

The problem, then, becomes one of establishing a system of navigation which is independent of weather, darkness, and human error. The solution consists of the following system: Power transmitters supply current, at two separated frequencies, to two cable loops located in the bed of the channel. The two cables provide a 2-way traffic lane on the seaway. In the watercraft a receiver picks up the radiated signal and transfers it to a visual indicator; thus the craft is guided along the cable in much the same way that a car follows the road. (Radiation is considered here as a loss of electromagnetic energy from a system, a current-carrying cable, into the medium of water.)

Essentially full text of the first-prize student branch paper for District 14 in the 1959-60 competition. Recommended for publication by the AIEE Educational Publications Committee.

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THEORETICAL BACKGROUND

To cope with the problem of signal transmission in a medium such as sea water, it is necessary to apply the laws of electromagnetic field theory. The analysis of the problem begins with the current-carrying cable in sea water.

As a first approximation, it can be assumed that the cable is in an infinite medium of sea water. This assumption provides a simplified approach to the problem. The reflection from the bottom of the channel or river does not decrease the strength of the signal that will be received at the surface of the water. In fact, it will increase it to some extent, depending on the mineral composition of the marine bottom.

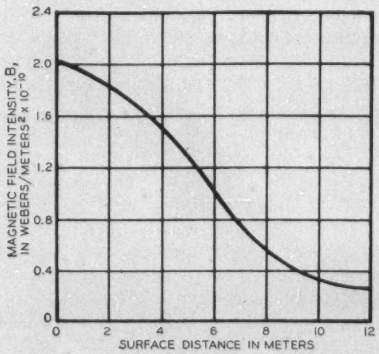

Fig. 1. Variation of B *with* R. *The radiating cable is at a depth of 15 meters below the surface of water. The variation is symmetric about the* B *axis*

Therefore, the assumption of an infinite medium is well founded.

At the surface of the water, the signal is received by two pickup loops at the bottom of the ship's hull. The signal strength required at the point of reception is arbitrarily set at 1 mv (millivolt). This signal strength is sufficient to be readily picked up by an

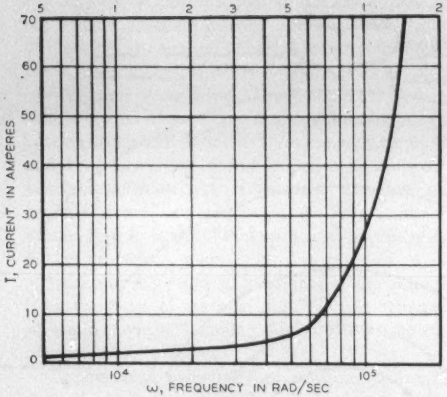

Fig. 2. Variation of current with frequency

amplifier having no special sensing circuitry. The signal is equal to

$$-N\frac{d\phi}{dt} = e = 1 \text{ mv} = 1 \times 10^{-3} \text{ volt}$$

If a sinusoidal excitation is assumed, then

$$NAB\,\omega \cos \omega t = 1 \times 10^{-3} \text{ volt} \tag{1}$$

where

N=number of turns of coil
A=area of the coil in square meters
B=magnitude of magnetic field intensity in webers per square meter
$\omega = 2\pi \times$ frequency in radians per second

The equation for the B field at a radial distance R from a current-carrying cable is[1]

$$B = \frac{\mu_o I}{2\pi R} \exp -\frac{R}{\delta} \tag{2}$$

where δ is the skin depth penetration and has the relation

$$\delta = \sqrt{\frac{1}{\pi f \mu_o \sigma}} = \sqrt{\frac{2}{\omega \mu_o \sigma}} \tag{3}$$

where

μ_o=permeability (4×10^{-7} henry per meter)
I=current, amperes, a function of ω
δ=skin depth, depth of penetration
σ=conductivity, mhos per meter
R=radial distance from source, meters

For sea water, $\sigma = 4$ mhos per meter and $\mu_r = \mu_o$, because $\mu_r/\mu_o = 1$ for non-magnetic materials

From equation 2, it is seen that B field is a function of R, δ, and I. For a constant current I (function of ω) the B field can be expressed as

$$B = \left(\frac{K}{R}\right)\left(\exp -\frac{R}{\delta}\right) \tag{4}$$

where $K = \mu_o I/2\pi$, and therefore B becomes only a function of R. The first part of the right-hand side of equation 4 represents a hyperbolic decay, and the second part, an exponential decay, for increasing R. Fig. 1 shows the variation of B with R.

It now becomes necessary to establish a frequency, ω, and to obtain a distribution of $B = f(R)$. This distribution has to be such as to give maximum variation of B field at the surface of the water, and yet limit attenuation to a practical minimum. The surface distance is measured to the right and to the left of the perpendicular to the axis of the cable. We assume here a depth of 15 meters for the distance R. This assumption is quite valid, since most channels are 30 to 40 feet deep, and the rivers have a navigable depth of approximately the same magniture.[2]

Now, to consider the signal at the point of reception, this signal is received by a pickup loop for which $NA = 50.1$ turns per square meter. (Details of the pickup loop will be discussed later). Then

$$(B\omega)\,(50.1) = 1 \times 10^{-3} \text{ volt} \tag{5}$$

or

$$B\omega \cong 2.0 \times 10^{-5}$$

The induced voltage e at the surface of the water depends upon B field for a given ω. For this relation

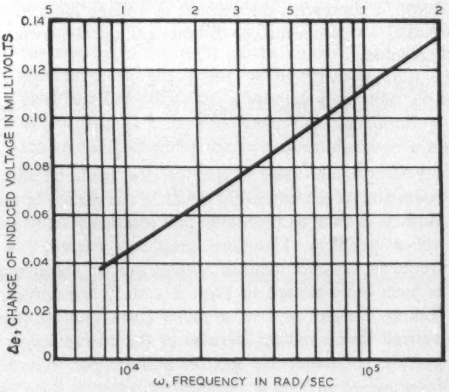

Fig. 3. Variation of induced voltage with frequency

see equation 2. Now, a value of ω is selected and equation 2 is solved for I:

$$I = \frac{2\pi RB}{\mu_o} \exp \frac{R}{\delta} \tag{6}$$

Holding I and ω constant, the B field is recalculated with a variation of the distance along the surface of the water to a point $R_1 > R$. Thus

$$B = \frac{\mu_o I}{2\pi R_1} \exp -\frac{R_1}{\delta} \tag{7}$$

The magnitude of the induced voltage is

$$\Delta e = (50.1)\,\omega \Delta B \tag{8}$$

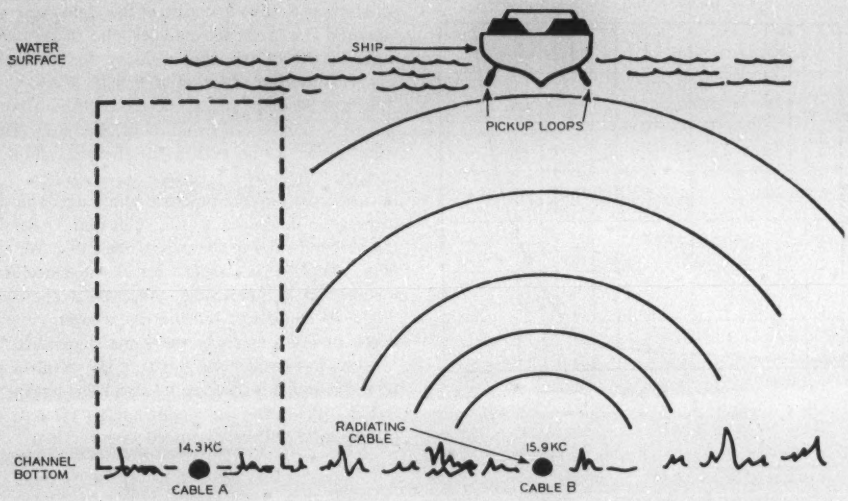

Fig. 4. Cross-sectional view of a channel indicating the interaction between two parallel radiating cables and a ship navigating with the system

where ΔB is the difference in the B field from equations 7 and 5, for a given angular frequency ω. The term Δe represents the amount of voltage induced in pickup loops at a surface-distance change of 2 meters. To solve

$$B = \frac{\mu_o I}{2\pi R} \exp\left(\frac{-R}{\sqrt{\frac{2}{\omega\mu_o\sigma}}}\right) \qquad (9)$$

for an optimum value of ω at which I would be minimum and Δe maximum for distance change along the surface, would be a tedious and mathematically involved problem. Therefore, graphs of current I vs. frequency ω and induced voltage Δe vs. frequency ω have been plotted in Figs. 2 and 3, respectively. Taking the plot of I vs. ω under consideration, it is noticed that a radical increase of the current occurs past the point $\omega = 10^5$ rad/sec (radians per second), for small changes in ω. A graph of Δe vs. ω shows a steady increase of Δe for increasing values of ω. Therefore, current as a function of ω becomes the determining factor. The values finally selected as points of operation are $\omega = 10 \times 10^4$ rad/sec, at which $I = 28$ amperes and $\Delta e = 0.115$ mv and $\omega = 9 \times 10^4$ rad/sec at which $I = 21.5$ amperes and $\Delta e = 0.113$ mv. The reason that two frequencies are used is that two cables are necessary to provide a 2-way traffic in a given waterway, with one frequency used for the "up" traffic, and the other for the "down" traffic. Filters in the ship's receiver will prevent any interference between the two signals should the cables be near enough to cause such effects. This, however, would not often be the case.

Having studied the theoretical background of the system, and to illustrate the system in use and the problems therein, a hypothetical case will be considered. The figures involved give a better understanding of the system and a good practical application. Let a channel in the New York Harbor be the hypothetical case.[2] Its length is 4 nautical miles, its average depth, 40 feet. Each section of the system will now be studied in detail.

COMPONENTS

Transmitting Cable. The specifications of the cable appear under "Cable Specifications" in the appendix. These specifications are calculated for a 10-mile cable length. Of this, only 5 miles, or approximately 4 nautical miles, are used in the actual transmission, while the remaining half is used as return loop for the signal. The loop originates and terminates at a transmitting station that supplies the necessary power. A return loop, rather than ground return, is used for better control of the signal. The return loop eliminates possible stray radiation from power lines in the vicinity, and provides a better matching and frequency control. The return cable is placed about 100 feet or more away from the "lead cable" and is shielded to eliminate any interference between the two. The channel widths average about 700 feet; thus the return loop is well within the channel boundary.

Because of the large spacing, the problem of two parallel current-carrying conductors in conducting medium can be considered as two separate conductors. The inductance and capacitance interaction between the two is negligible.

Referring to Fig. 4, assume that the distance between cable A and cable B is twice the distance from either cable to surface, or about 100 feet. Cable A

can be isolated into the area within the dashed line, the area of practical interest in the system. Because of the large attenuation of signal transmitted through water, the effect of cable *B* on cable *A* is negligible.

Reception of the Signal. The signal received by the ship is the induced voltage in the pickup loops at the bottom of the hull. Relatively low frequencies of 14.3 and 15.9 kc do not permit effective use of rod or parabolic reflector type of antennas; therefore pick-up loops have been employed, the specifications of which appear under "Pickup Loop Specifications" in the appendix.

Since the reception of the signal at the surface is from two sides of the boat hull, the two "channels" of the receiver are similar. Fig. 5 shows the block diagram of the receiver.

The receiver, essentially an audio amplifier, consists of a preamplifier followed by two additional stages. A shunting resistor (gain control) in the output of the preamplifier is used for compensation of signal inputs to channel depths.

A high-pass and a low-pass filter are used in the receiver to enable the ship to select only the signal of the cable which it desires to follow. If the ship follows the 14.3-kc cable, the low-pass filter would be used and, conversely, if it follows the 15.9-kc cable, the high-pass filter would be used. The filters are designed for a cutoff frequency, ω_c, of $\omega = 9.5 \times 10^4$ rad/sec with a 0.5×10^4 rad/sec safety margin on both sides of the ω_c. The filters are placed after the preamplifier stage in order to keep a high signal-to-noise ratio.

The two channels of the receiver, each with a gain of approximately 250,000, have a separate load, an indicator, which is a milliammeter placed in the output of the last amplifier stage. A variable shunt resistor is placed across the coil of the meter to provide a control of current flowing in the meter; this permits calibration of the indicator. Although the indicators are separate in their functioning, both are contained in a common housing.

To explain better the functions of the indicator, a situation is considered of a boat navigating by the system described.

Refer to Fig. 4 for relative position of the transmitting cables and a moving ship. When the ship travels directly above the cable, both of the loops receive the same strength of signal, which is less than at the center of the boat. This is due to the symmetric drop of *B* field about the perpendicular to the axis of the cable, as distance is increased horizontally from this point. If the ship moves off the cable to the right, the left antenna will receive a signal of greater strength than before, and the right antenna will receive one of less strength. The inverse is true if the ship moves to the left of the cable.

To return to the indicator and its operation, let us examine the face of the housing illustrated in Fig. 6. The meridian line is a perpendicular bisector of a line connecting bases of the meter needles. The position of the point of intersection of the two needles relative to the meridian line indicates the position of the ship relative to the cable. That is, when the point of intersection is to the right of the meridian line, the ship is to the right of the cable. Also, the displacement of the point of intersection from the meridian line will give a relative indication of the ship's distance from the cable. (The relationship of the signal strength to the horizontal distance is nonlinear but a scale could be developed to show this variation.) No calibration is necessary on the indicator face as we are concerned only with position at

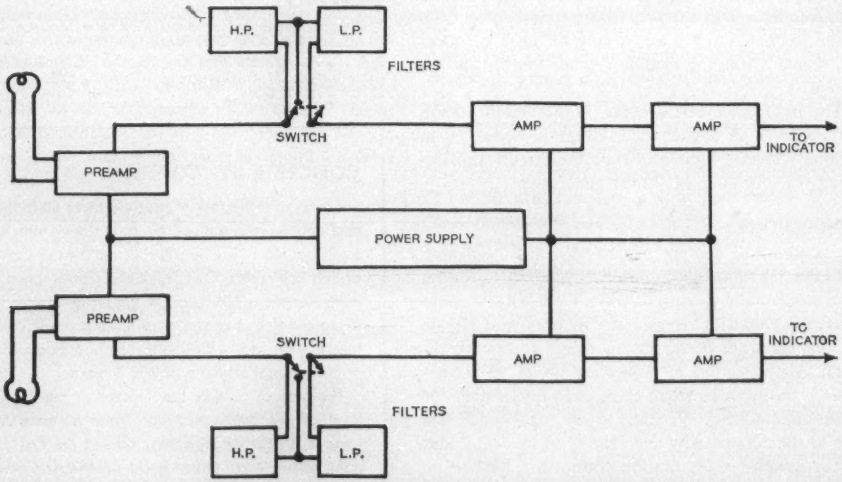

Fig. 5. Block diagram of the receiver. Both "channels" of the receiver are shown

the point of the intersection with respect to the meridian line.

This indicator may also be used as a depth meter, where the intersection of the two needles on the meridian line relative to the base line will be a function of the depth. The function is nonlinear, but a scale on the meridian line could be developed for depth measurements. The salinity of water is assumed

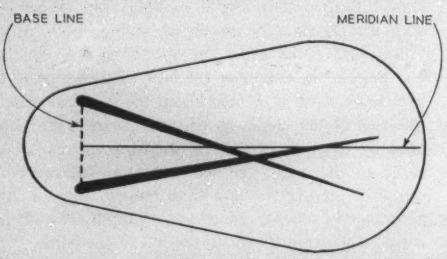

Fig. 6. Face of the indicator showing the relative position of the ship to the cable. The ship is to the right of the cable

to be homogeneous. This would, perhaps, require initial adjustment of preamplifier output and shunting resistors of the indicator coils upon entering each new channel.

Power Generation. To radiate the required signal, one cable must carry 28 amperes at a frequency of 15.9 kc, while the other carries 21.5 amperes at a frequency of 14.3 kc. The resistance of a 10-mile length of no. 0 wire is 5.19 ohms; thus it is necessary to generate about 4.5 kw of power. It is to be noted that two generators are required, one for each cable. The solution presents itself in two forms. First, a crystal-controlled MOPA (master oscillator, power amplifier) system and, second, a rotating machine with frequencies in a 10- to 20-kc range. In fact, up to the frequency of 15 kc, it may be more economical to use a rotating machine rather than a MOPA system.

The inductance of the cable loop is about 10 mh (millihenrys). A capacitance, either in series or in parallel with the loop, will tune the circuit and improve the efficiency of power generation.

CONCLUSIONS

The system, as presented, provides easy, efficient, and effective control of marine navigation traffic on the commercially used waterways. Generally, it could be used in channels, rivers, bays, harbors, and canals, but the variation of depths in these waterways requires compensation in power output of the transmitters, and perhaps slight changes in frequencies for maximum efficiency. Needless to say, local conditions such as the conductivity and salinity of the water and the topography of the marine bottom will have to be known in each case. The receivers are designed for operation under a wide range of conditions. Specific adjustments of signal reception may be made by the navigator.

It is to be noted that the system proposed does not necessarily replace the present system of markers and buoys, but supplements it. Advantages of the system are:

1. Weather conditions have no effect on the system. This eliminates the potential dangers due to inaudibility of the bells and whistles on the markers during calm or storms, invisibility at night and in fog, and human error caused by ignorance or inexperience.

2. To the navigator it offers a simple but clear guidance system which enables him to guide his ship through a busy channel or undulating river with the greatest of ease, regardless of weather.

3. The system has no practical limitations on the size of the craft. Private, as well as commercial, vessels are well adapted to the system.

Appendix

CABLE SPECIFICATIONS

The cable to be used is AWG no. 0, pure copper, single strand wire.
Resistance, Ohm per 1,000 feet = 0.0983
Weight, pounds per 1,000 feet = 319
Current capacity = 230 amperes
Length of the cable = 10 miles (this includes outgoing and return loop)
Total resistance of cable = 5.19 ohms
Total weight of the cable = 16.7×10^3 pounds = 8.35 tons

PICKUP LOOP SPECIFICATIONS

No. 30, AWG, pure copper wire is used with shellac insulation.
Resistance = 103.2 ohms per 1,000 feet = 0.334 ohm per meter
Weight = 0.304 pound per 1,000 feet = 0.997×10^{-3} pound per meter
Mean Area = 50.1×10^{-4} m²
Mean Diameter = 7.99 cm
Mean Circumference = 25.03 cm
Number of turns = 10^4
Length of wire = 2,503 m
Total Resistance = 8.35×10^3 ohms
Total weight = 2.50 pounds
The coil of wire is enclosed in a plastic envelope and has a plastic mounting.

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1. Electro-Magnetics (book), J. D. Kraus. McGraw-Hill Book Company, Inc., New York, N. Y., pp. 400-03.
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CONCRETE BY 'COPTER

Faced with the task of erecting three 60-foot transmission towers in a mountain pass strewn with house-sized boulders, Southern California Edison Company and its contractor, Owl Truck and Construction Company, turned a 1,700-pound 305-hp helicopter into a flying ready-mix concrete truck. As a result, all three towers were ready for line stringing in 2 days instead of the original estimate of 2 to 3 weeks.

The project, a 66-kv line located at the 2,000-foot level of the bulldozer-proof Santa Susanna Mountains in Southern California, marked the first time a light 'copter was used to build steel powerline structures from the concrete foundation up.

R. L. WINSHIP

Static overcurrent tripping device for low-voltage breakers

In an effort to overcome some of the outstanding shortcomings of presently used electromechanical tripping devices, a static type using semiconductors has been developed. Advantages include greater accuracy, simplified field testing, greater flexibility, and reduced maintenance

Low-voltage air circuit breakers rated at 600 volts and less are used as protective and switching devices on plant distribution systems. They may be installed in metal-clad switchgear, on switchboards, or they may be separately mounted. Designed to interrupt currents of 15 to 100 kiloamperes at 600 volts (and higher at lower voltages), these breakers are necessary for complete system protection where the greatest degree of service continuity is desired.

Low-voltage breakers are normally equipped with series overcurrent trip devices which detect and time the overcurrent in the circuit. These trip devices are placed directly in the circuit being protected, except in some high-current applications when current transformers are used. The trip device uses the energy of the overload both to operate the timing mechanism and trip the breaker. No secondary power source is required for tripping. The trip devices now being used are electromechanical and have certain inherent deficiencies.

In an effort to overcome the deficiencies of the electromechanical design, a trip device using only nonmoving (or static) components has been developed. The device is actually an electronic circuit using semiconductors. Among the many advantages it offers to the user of low-voltage circuit breakers are:

1. Simplified field testing
2. Ease of changing the continuous-current rating of a breaker
3. Reduced maintenance on trip devices
4. Greater flexibility in trip device characteristics
5. Better co-ordination with fuses, relays, and other protective equipment
6. More selective protective equipment operating in series
7. Better over-all system and equipment protection through a more accurate trip device

A comparison of the electromechanical series overcurrent trip device and the static trip device will illustrate some ways in which the latter will benefit the breaker user and his system.

Essentially full text of a conference paper presented at the AIEE Spring Textile Conference, Atlanta, Ga., May 4, 1961.
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TYPICAL ELECTROMECHANICAL TRIP DEVICE

A brief description of the electromechanical device will give a basis for comparison with the static device. Fig. 1 is a 3-phase assembly with the series trip coils and cores of two phases removed. Each of the single-phase devices contains a series trip coil, is independently adjusted, and operates independently.

Fig. 2 is a cutaway view of one of the single-phase electromechanical devices. Current in the series coil (2-2) sets up a magnetic field in the core (2-5). The armature (2-1), pivoting about the shaft (2-3) is attracted to the core by the magnetic field. However, before the armature starts to move, the current in the series coil must be sufficient to overcome the force of the pickup spring (2-4), which holds the armature away from the core. As the magnetic force becomes large enough, the armature quickly moves toward the core, engaging a tripping block on the breaker. This action produces the instantaneous tripping characteristics. As the breaker opens, the current in the coil falls to zero and the pickup spring returns the armature to its original position.

To obtain the time-delay characteristic desired in the trip device, a time-delay device (Fig. 3) is attached to a right-angle leg on the armature. (This does not show clearly in the illustration.) As the armature is pulled toward the core (after the pickup spring force has been overcome), its motion is retarded as the silicone oil in the lower chamber of the time-delay device is displaced into the upper chamber. The metering element (3-1) through which the oil must pass provides accurate timing. The check valve (3-2) allows the device to reset quickly. In this

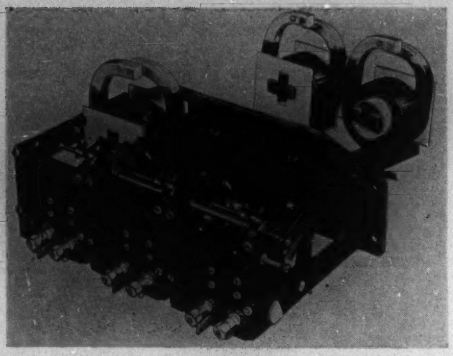


Fig. 1. A 3-phase series overcurrent trip device for a low-voltage air circuit breaker. Trip coils removed from two phases

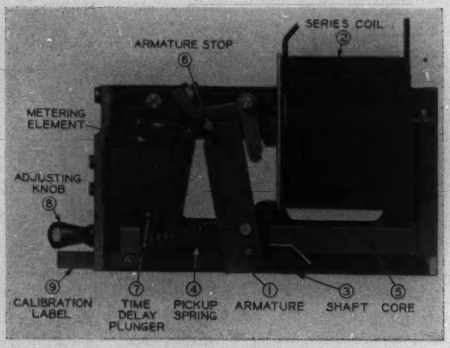


Fig. 2. Cutaway view of series overcurrent tripping device showing basic components

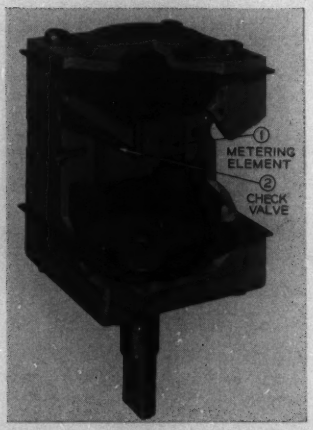


Fig. 3. Cutaway view of the hermetically sealed positive-displacement time-delay device as used on low-voltage overcurrent tripping devices

device separate armatures are used for the instantaneous and the time delay characteristic.

The electromechanical device is adjustable in several ways, providing a wide range of time–current characteristics. The points of adjustment are:

1. The point at which the time-delay plunger (2-7) is attached to the armature. This varies the force applied to the plunger, thus varying the time delay for a given current.

2. The porosity of the metering element. Two metering elements are available: one for a long time delay and one for a short.

3. The tension on the pickup spring. This varies the pickup current (i.e., the current required to start the armature moving). The adjusting knob (2-8) varies the pickup spring tension and the label (2-9) indicates the pickup level.

TIME–CURRENT CHARACTERISTICS

A typical time–current characteristic for an electromechanical series trip device is shown as the cross-hatched area in Fig. 4. The unavoidable tolerances of the electromechanical device, coupled with the effect of resettable delay time, result in a range of tripping times. Thus, when a low-voltage breaker is applied, it is necessary to consider the tripping characteristic as an area rather than a single line. As the tolerances in the trip devices are reduced, the tripping characteristic can be described by a smaller area.

The electromechanical device is made up of separate elements for long and short time delay. When they are placed together on a breaker for selective application, the tripping characteristic is seen to have a distinct and undesirable hump, the removal of which would be advantageous in the application of these breakers.

To improve the present time–current characteristics it is, therefore, desirable (1) to reduce the area required to describe the characteristic (to a single line if possible) and (2) to describe the characteristic by a straight line or lines.

STATIC OVERCURRENT TRIP DEVICE

A typical time–current characteristic of the static trip device is shown in Fig. 4 superimposed on the typical electromechanical device characteristic. The new characteristic is straight and its bandwidth has been reduced considerably compared to the conventional one. Some of the advantages of this new characteristic are discussed later.

Fig. 5 is a block diagram of the static trip device. The three current transformers mounted on the circuit breaker studs provide a small low-voltage secondary current proportional to primary current. The secondary of each current transformer is connected in series with an auxiliary transformer and a resistor in parallel with a potentiometer as shown. Output of the auxiliary transformer is rectified to provide

d-c energy for the trip coil and also a regulated d-c power supply to operate the transistor circuit.

An a-c signal voltage proportional to the primary current which acts as the intelligence input for the device is provided by the resistor. Magnitude of this alternating voltage determines whether or not the breaker will trip, and the time delay before tripping. Adjustment of the potentiometer will vary the relation between the a-c signal voltage and the primary current in the breaker. This potentiometer adjustment varies the minimum primary current at which the breaker will trip and is referred to as the "pickup adjustment."

The a-c signal voltage is rectified and filtered. If the signal is above a value set during factory adjustment, the trigger will operate. This trigger is a transistor circuit which, in effect, prevents operation of the timing circuit unless the signal exceeds the pick-up value.

The d-c signal goes through a circuit designated as "time shaping," since it determines the shape and slope of the time–current characteristic curve. The output from the "time-shaping" circuit actuates a transistor circuit which has been labeled "oscillator" because its output is in the form of pulses at a frequency which varies with the signal voltage. This output goes to a timing circuit which is essentially an *R-C* circuit. If the trigger has operated, a capacitor will charge gradually to a voltage which causes the static switch to operate, energize the trip coil, and trip the breaker. If at any time before the static switch actually operates, the primary current decreases to about 90 per cent or less of the pickup value set on the trip device, the trigger will turn off and reset will take place.

Time delay at any specific value of primary current may be varied over quite wide limits by changing the resistance in the timing circuit. Curves for the static trip device will be published at three different values of resistance in the timing circuit. Thus, a long time band, an intermediate time band, and a short time band timing characteristic will be available. The three time–current characteristics will have the same shape, but will be displaced vertically on the time–current co-ordinates.

TIME–CURRENT CHARACTERISTIC OF STATIC TRIP DEVICE

The tripping characteristic of the static trip device is shown as the dotted area in Fig. 4. The equation of the long portion of the curve is $T = K/I^n$ where T is time, K and n are constants, and I is current. When this function is plotted on log-log co-ordinates, it shows as a straight line. Thus $\log T = \log K - n \log I$. This is an equation of the form $Y = a - bx$.

Therefore, it follows that by varying K, the curve is moved vertically. Also, as the value of n changes, the slope of the curve changes.

The static trip device is designed so that n and K

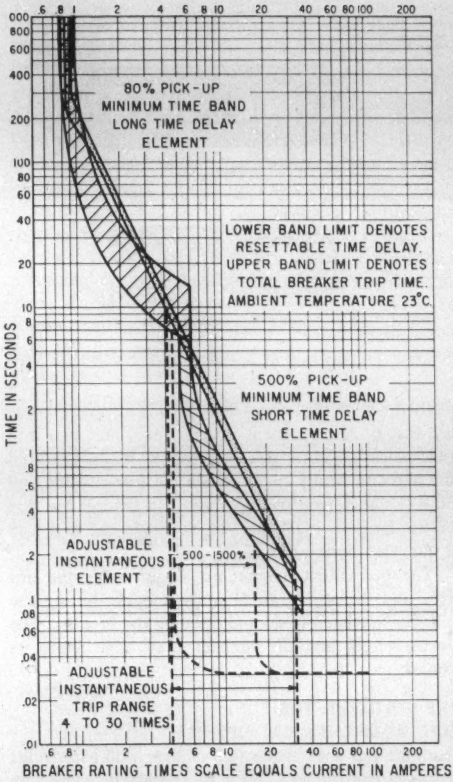


Fig. 4. Ideal time–current characteristic (dotted area) superimposed on typical characteristic that currently is existent on low-voltage breakers (cross-hatched area)

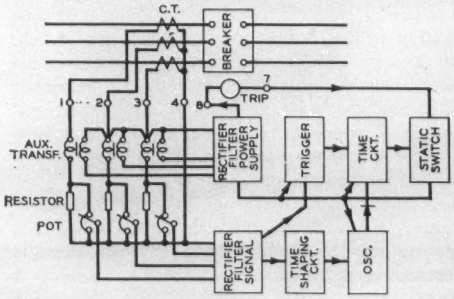


Fig. 5. Block diagram of static overcurrent trip device

may be varied to produce different tripping characteristics. The time-band adjustment on the front of the trip device continuously varies K, moving the curve vertically. The value of n, varying the slope of the curve, may be changed at the factory.

Extremely rapid tripping of the breaker is accom-

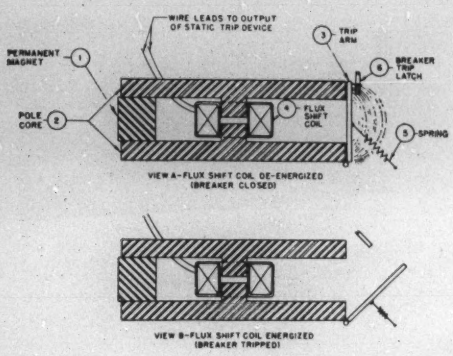


Fig. 6. Flux-shifting magnetic latch

plished with a low energy flux-shifting magnetic latch; see Fig. 6. A permanent magnet (6-1) and two iron pole pieces (6-2) form a "horseshoe" magnet to hold the trip arm firmly (6-3). When the flux-shifting coil (6-4) is energized by the static trip device, the flux of the horseshoe magnet which holds the trip arm is canceled by the flux of the coil.

The permanent magnet no longer holds the trip arm and the spring (6-5) pulls it back, hitting the breaker trip latch (6-6) and opening the breaker. The device resets and the breaker may once again be closed.

THE STATIC VS. THE ELECTROMECHANICAL DEVICE

Both the physical application of the static trip device to the circuit breaker and its time–current characteristic offer advantages over the devices now being used. Some of these advantages are:

1. *Simplified Field Testing.* The static trip device is a low-power device, and therefore requires only low power to test its circuitry. Although it is quite difficult to field test a conventional device because of the very high currents required, the new static device may be tested rather easily with conveniently sized equipment. As an example, a 75-kva transformer is needed to test at the highest rating of a conventional series device, but only 3 to 4 kva is needed for the static device.

2. *Simple Field Conversion to a New Continuous Current Rating.* The continuous current rating of a breaker may be changed by merely replacing the special current transformers mounted on the breaker studs.

3. *Reduced Maintenance.* Since the static trip device has no moving parts, it will not require any mechanical maintenance. If the electric components are damaged through improper testing, the entire device may be removed and replaced with an identical unit.

4. *Greater Flexibility in Trip-Device Characteristics.* The trip curve is nearly a perfectly continuous straight line. The position and slope of the line may be varied widely over the usable range. The standard instantaneous tripping range will be increased to 4 to 40 times pickup current from the 5 to 15 now available.

5. *Better Co-ordination with Fuses.* The use of current-limiting fuses on low-voltage circuit breakers is becoming increasingly popular and should continue in that direction. Fuses are mounted directly on the breaker and permit the use of a small frame size breaker within the continuous current requirements of the system even though the system short-circuit capability is in excess of the breaker rating. The fuse and breaker are co-ordinated so that the fuse interrupts only on short circuits in excess of the breaker rating.

Fig. 7 shows the co-ordination between a fuse and 600-ampere breaker using both types of overcurrent trip devices. Where the electromechanical device set on the maximum time band is used, a 2,000-ampere fuse is required. With this combination, the instantaneous trip must be set at about 6,000 amperes. If

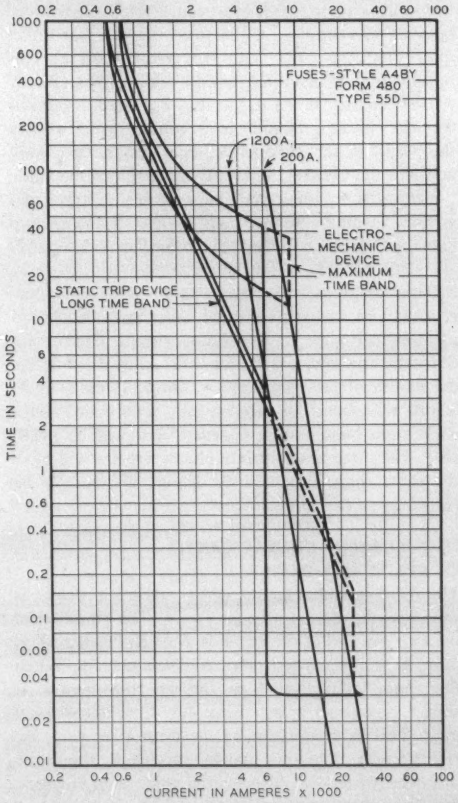


Fig. 7. Co-ordinating breaker trip characteristics with fuses

the static trip device is used in place of the electromechanical device, a 1,200-ampere fuse rather than the 2,000-ampere unit previously required will coordinate with the breaker. With the new arrangement a small, less costly fuse can be used to build a fully selective unit.

The total area consumed on the time-current layout for a fuse and breaker combination is reduced considerably when the static trip device is used. This is because the characteristic of the fuse is similar to that of the trip device, and the two curves may be placed quite close together as a result of reduced tolerances on the new device. The compact time–current characteristic will give better selectivity in tight applications. As an example, in applications where the breaker trip curve has infringed on the fuse-damage zone, the static trip device may eliminate the interference and thereby provide better selectivity.

6. *More Protective Equipment May Be Operated Selectively in Series.* Reduced tolerances on the tripping characteristic, the straight-line form of the characteristic, and a far more accurate resetting characteristic will allow a larger number of breakers and fuses to be applied selectively in series. The selectivity of the protective devices will extend even beyond the 600-volt system.

The tripping characteristic may be defined more accurately, since tolerances have been reduced. This means that more breakers may be arranged to operate within a given time–current range.

Less area on the time–current layout is consumed by a static trip device co-ordinated with a fuse because of their similar characteristics; hence, there are more selective units in series.

In the static trip device, the 60-cycle vibration and inertia associated with electromechanical devices has been eliminated. As a result, the resetting characteristics are far more accurate and predictable. The static trip device will reset very rapidly when the current falls to about 90 per cent of pickup; therefore, breakers may be applied with their time–current characteristics placed quite close together.

7. *Better Over-all System and Equipment Protection Through a More Accurate Trip Device.* The static trip device provides a far more accurate means of tripping low-voltage circuit breakers than has been previously available. The tripping characteristic (not just the pickup value), is defined at least 70 per cent more accurately than on presently available devices. This characteristic is stable over a temperature range of 0 to 55 C. The high accuracy of the static trip device will permit the greatest degree of selectivity consistent with complete protection.

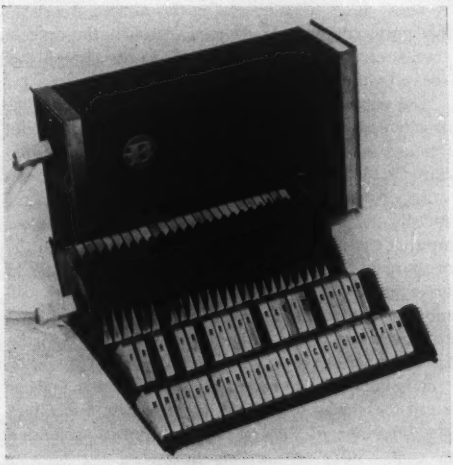
MADDAM—A HIGH-SPEED MINIATURIZED COMPUTER

A complete miniaturized working electronic computer—the size of a loaf of bread yet capable of performing calculations at the speeds of a room-size computer—has been demonstrated by the Burroughs Corporation. The tiny computer is a single-purpose "brain" that could solve many single-purpose commercial or military problems calling for speeds of a computer. It was shown as it might be used by the military to solve a target chase-and-catch problem from an airplane, spacecraft, or missile.

The computer was developed by Burroughs at Paoli, Pa., after several years of company-sponsored research and development. The basic design goal was a practical miniaturized computer which could be built of conventional commercially available components and which satisfactorily dissipated the heat generated by the components.

Called MADDAM (the name is derived from MAcro-Module and Digital Differential Analyzer Machine organization), the computer has 5,500 components housed in a space measuring 3 by 6 by 11 inches and a component density of 69,000 components per cubic foot. The computer weighs 12 pounds and can perform 33,000 calculations per second.

The Macro-Module method has a finned heat exchanger as a central element in a "log" or row of triangular chips, which contain electronic circuitry and plug into a folding printed circuit board. Additional compactness is obtained by folding (or actually wrapping) the board holding the upright chips around the head exchanger. Two rows of



chips, each 3 inches square and 10 inches long, contain the circuitry, logic, memory and other working parts of the computer.

The Macro-Module packaging method incorporates unusual flexibility into computers produced by the method. The size of the computers may be increased to meet varying demands by extending the base printed circuit board and adding to the number of chips used.

W. C. SCHMIDT and R. R. POTTS

Speed regulation by digital methods

By application of digital techniques to a speed-regulating system, it is possible to regulate the controlled variable to accuracies not attainable by other methods. The development of a typical system is described.

The development of digital technology over the past 20 years has opened the way to vast new areas of industrial uses. The number of such uses is already large and is growing at an accelerated rate as day by day the potential of these techniques gains wider recognition.

The value of the digital approach to a precision speed-regulating system is twofold:

1. It is possible to regulate the controlled variable to an accuracy not attainable by other methods.
2. It lends itself to control by punched tape and cards and other forms of automatic programming.

The heart of the system is a digital error register. A more descriptive name for this device is reversible pulse counter. As its name implies, the register counts electrical pulses applied to its input, and does so with exact precision.

The counter has two inputs. Pulses applied to the so-called positive input cause the register to count forward, while pulses applied to the negative input cause it to count in reverse.

Suppose there are two separate pulse sources, *A* and *B*, and that source *A* is applied to the positive input of the register, while source *B* is applied to the negative input. Each *A* pulse will add one count to the contents of the register, while each *B* pulse will subtract one count. The error register will then keep exact account of the instantaneous difference in the total number of pulses generated by sources *A* and *B*.

It is important to recognize that the error register it not measuring difference in frequency, but rather the difference in total number of pulses generated by each source. No matter how long the register has been counting—even for hours—if in that time one source has generated a single pulse more than the other, the register indicates the fact. Herein lies the extreme accuracy attainable with this system. The error register is really a digital integrator with a long memory.

In this system, sources *A* and *B* are replaced by reference and feedback elements, as in Fig. 1. The reference pulse train is generated by a crystal oscillator. Crystals having frequency accuracies and freedom from drift of up to one part per million are

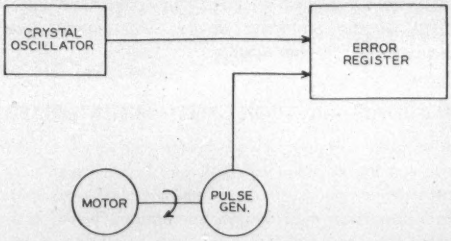


Fig. 1. Basic system

common. This means the reference can be made extremely precise.

The feedback pulses are generated by a transducer driven by the controlled element, in this case a motor. The transducer is such that one feedback pulse is generated for each increment of rotation. As an example, a typical installation would use a feedback-pulse transducer that generates several hundred pulses per motor rotation.

If the reference and feedback pulse trains are fed into the error register, and the net accumulated difference in the count is observed, an extremely accurate means of measuring motor speed against a precise crystal oscillator is obtained. If the motor speed is adjusted to keep the net count in the error register to exactly zero, then motor speed is being regulated to the same accuracy as the crystal oscillator: one part per million or better.

The system of Fig. 1 as it stands, is not capable of regulating motor speed automatically. Only the means for measuring motor speed against a reference is present. The required information is in the

Essentially full text of conference paper CP61-645, presented at the AIEE North Eastern District Meeting, Hartford, Conn., May 17-19, 1961, at a session sponsored by the AIEE Industrial Controls Committee.

W. C. Schmidt, Associate Member AIEE, and R. R. Potts are with Reliance Electric and Engineering Company, Cleveland, Ohio.

form of count signals in the error register. This information must be converted into a form directly usable to regulate motor speed.

To begin, an electrically regulated drive is added to control motor speed; see Fig. 2. A positive signal applied to the input of the motor regulator causes armature voltage and motor speed to increase. An input of 50 millivolts is sufficient to cause the regulator to apply full armature voltage to the motor. At this point a transition must be made from speed-error information as contained in the error register in the form of counts into a proportional direct voltage. This is accomplished with an element aptly named a digital-to-analog converter, which continuously monitors the contents of the register and generates a voltage proportional to the error count both in magnitude and polarity. This voltage is applied directly to the input of the electronic drive. A plot of error counts versus output voltage is also shown in Fig. 2. Notice that both quantities can be negative or positive.

The control loop is now complete. If there is any count in the error register, it is converted instantly to a d-c signal that is applied to the input of the electronic motor drive. The motor will respond by changing speed in such a direction as to reduce the error count in the register to zero.

To keep the system in balance, the voltage input to the electronic drive must be nearly zero; therefore, the count in the register must be zero. This condition is possible only if each reference pulse is cancelled immediately by a feedback pulse. Since the register is, in effect, an integrator, any difference between reference and feedback pulse rates, no matter how small, will be integrated, and a corrective

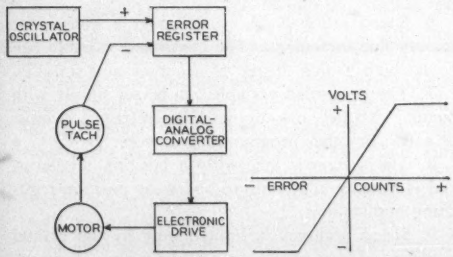


Fig. 2. (Left) *System with electrically regulated drive added.* (Right) *Error counts vs. output voltage*

voltage generated. Thus, there can be no steady-state speed error.

It can be shown that corrective action takes place before the system is in error by one count. All that is necessary is a small phase shift between reference and feedback pulse trains. The integrating properties of the register and the high steady-state gain of the system take care of the rest. Notice especially that a voltage-feedback tachometer is not required, since feedback is accomplished entirely by the pulse tachometer. Hence, another source of error inherent in most speed-regulating systems has been eliminated.

The system operates in a digital mode right up to the final conversion. Digital circuits are not subject to drift, nor are they sensitive to reasonable changes in pulse height, shape, etc. In addition, it can be shown that severe drift in the analog portions of the system have negligible effect on accuracy, which is limited only by the crystal, one of the most precise oscillating devices known. Therefore, it may be stated that the system represents the ultimate in precision speed control.

The system as represented in Fig. 2 has no provision for changing speed. Variable speed can be obtained by adding an element known in digital

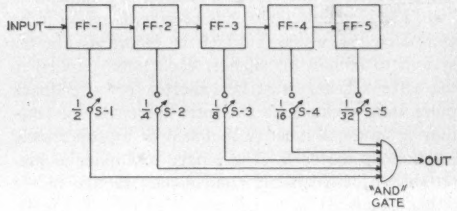


Fig. 3. Binary multiplier

computer circles as a binary multiplier; see Fig. 3. In spite of its technical name, the binary multiplier is more in the nature of a divider. Specifically, it can be set to deliver at its output some exact fraction of the pulses entering its input.

The multiplier consists of a number of so-called "flip-flop" circuits, which are connected in series. The flip-flop is a "divide-by-two" circuit, and delivers at its output exactly one half the pulses it receives. Thus flip-flop 1 (*FF-1*) in Fig. 3 delivers to both flip-flop 2 (*FF-2*) and switch 1 (*S-1*) exactly half the pulses it receives. Similarly, *FF-2* delivers to both *FF-3* and *S-2* exactly half the pulses it receives. But it received only the pulses fed into the first flip-flop; thus it delivers at its output only one fourth of these. In a similar manner, each successive flip-flop divides the number of input by two, and simple arithmetic shows that *FF-5* will deliver 1/32 of the input pulses.

The output of each flip-flop can be connected by a corresponding switch to an element called an OR gate, which mixes, or adds, the outputs of the individual flip-flops. As an illustration, assume that switches *S-1*, *S-3*, and *S-5* are closed, thus connecting the outputs of *FF-1*, *FF-3*, and *FF-5* to the OR gate, which then sums these outputs. *FF-1* contributes 1/2, *FF-3* contributes 1/8, and *FF-5* contributes 1/32 of the input pulses to the OR gate. Thus the output will be $1/2 + 1/8 + 1/32$, or 21/32 of the input pulses.

With five flip-flop elements, 32 different ratios,

variable from 0/32 to 31/32 in increments of 1/32, can be set up. Each additional flip-flop doubles the number of possible combinations. The number of flip-flops in a given unit is dictated by the specific application; units have been built with 13 flip-flops, giving 8,191 combinations. However, this by no means represents a limit to the number of combinations available.

It is this property of precisely controllable pulse ratios that makes the binary multiplier ideally suited for this application. In Fig. 4, a binary multiplier has been inserted between the crystal reference oscillator and the error register. In this way the number of reference pulses applied to the register, and hence motor speed, can be adjusted from zero to 100 per cent, in fine increments. At the same time, the precision of the crystal oscillator is retained.

In Fig. 5, the oscillator has been replaced by pulse tachometer *A*, which is driven by motor *A*. For the system to remain in balance, each pulse applied to the error register must be canceled by a feedback pulse from tachometer *B*. Every increment of rotation by motor *A* must be matched by a proportional rotation by motor *B*. The binary multiplier is presettable to deliver some controllable fraction of the pulses generated by tachometer *A* to the error register. Therefore, the ratio between motor rotations is determined by the setting of the binary multiplier.

In this way, the system becomes a position regulator as well as a speed regulator. In other words, it is the digital equivalent of a synchronous follow-up system. But unlike the synchronous system, it

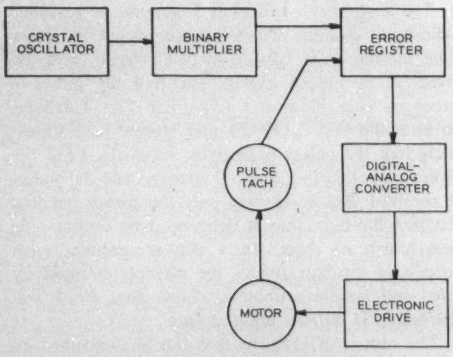


Fig. 4. System with binary multiplier inserted between crystal oscillator and error register

provides the means for varying speed and position ratios between lead and follow sections. Moreover, the ratios are readily adjusted in fine increments over the full range. In practice, changing the ratio is as simple as setting a group of switches, or inserting a punched card into a reader.

It might be well at this point to review the unique and useful characteristics of this system, as follows:

1. The error register is, in effect, a digital integrator with a long memory. Any speed or position error, however small, is integrated, and the motor speed is quickly corrected.

2. The system does not rely on time-based counting techniques, which suffer seriously from inherent dead times and counting errors.

3. It regulates on a pulse-to-pulse basis. Each reference pulse must be canceled immediately by a feedback pulse. Since the pulse rates involved are in the kilocycle range, corrective action takes place immediately and effectively.

4. It enjoys all of the advantages of digital circuitry correctly applied, including freedom from drift and the ultimate in accuracy.

5. No voltage feedback tachometer is necessary.

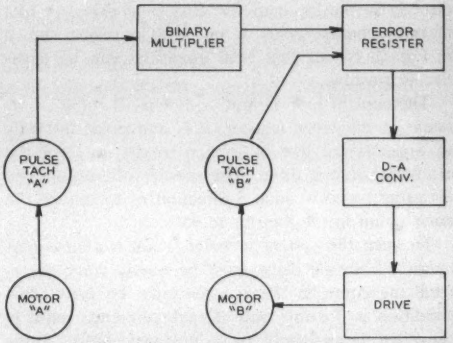


Fig. 5. System with pulse tachometer A, *driven by motor* A, *replacing crystal oscillator*

Feedback is provided entirely by the pulse tachometer.

6. Speed ratios can be varied over a wide range in very fine increments. The controlled variable can be set with a high degree of accuracy and stability.

7. The controlled variable can be set simply with manual switches, or automatically by punched tape, or cards, or other programming devices.

8. The system is inherently a position regulator, and is equally adaptable to speed or position-regulating applications.

9. Speed accuracy is limited only by the crystal oscillator. These oscillators are available with accuracies to several parts per million or better. When the system is used to vary position ratio, the accuracy is the same as if the motors were coupled by direct gearing.

This system fits well into many applications. The most obvious is the speed regulator of Fig. 4. Here a single motor is speed regulated very accurately.

Actually, more than one output can be taken from a single binary multiplier, and the ratio of each can be set independently of the other. This system, shown in Fig. 6, has two controlled outputs. Each channel

consists of an error register, digital-to-analog converter, electronic drive, motor, and pulse tachometer. The speed of either channel can be set independently of the other. Such a system is useful where both speed ratio and absolute speed accuracy must be

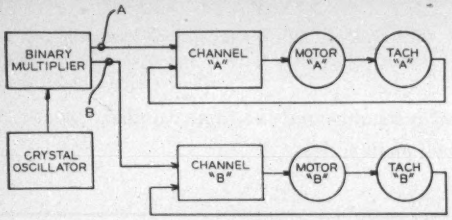


Fig. 6. System with two controlled outputs

controlled very accurately. Any number of motors can be independently controlled.

The system of Fig. 6 forms a precision "draw" control. Motors *A* and *B* each control a separate section, and the speed of each is independently adjustable, but precisely referenced to the oscillator. Thus, their speed ratios remain constant. Again, any number of sections can be controlled.

The system of Fig. 6 is applicable to a machine tool, such as a lathe or milling machine. If the motors were coupled to the lead screws driving the milling machine table, a straight, sloping line would be milled. The slope would be determined by the ratios set into the binary multiplier. If the slope of the line were continually changed, a series of straight lines approximating a curve would be milled, as shown in Fig. 7.

For example, the ratios in the binary multiplier could be set so that the speed ratios between the motors were just right to mill the straight-line segment from *A* to *B*. Then, at point *B*, the ratio could be changed to mill the segment from *C* to *D*. This process would continue until a whole series of lines approximating the curved section had been milled. If the segments were kept short enough, the approximation to the curve would be very close. The whole process could be controlled by punched tape, which could change the binary multiplier ratios in just the right manner to generate the desired curve.

In most applications speed ratio, rather than absolute speed accuracy, is desired. If this is the case, the crystal oscillator of Fig. 6 could be replaced by a conventional oscillator.

Controlled acceleration is also available, simply by replacement of the fixed-frequency oscillator by a variable-frequency unit. This oscillator could be made to change its frequency from a very low to a high value in a linear manner. All motors, being referenced to this oscillator, would accelerate to running speed, maintaining a constant speed ratio between them throughout the process.

The follow-up system of Fig. 5 can be applied to "draw" control. In this case, motor *A* would be the lead section, and motor *B* the follow section. Again, speed ratio is controlled by the setting on the binary multiplier. Any number of these sections may be cascaded. For example, the output of tachometer *B* could serve as the input for the binary multiplier of section *C*, and so forth.

There are many areas of application for the control of speed and speed ratio between sections of a machine. There is not sufficient space to describe them all in detail, but they include, besides the ones already discussed, cut-to-length control, control of registry to a printed mark, and control of build-up of material on a coil.

We are headed in the direction of true computer control of continuous processes, sometimes called "adaptive control." Many of the continuous processes that we know today are quite complex, and the relationships between the controllable variables in the process and the quality of the output are complicated. Steel rolling offers an example. The gauge of the finished product depends upon many variables, including temperature, speed of the individual rolling stands, reduction of the strip at each rolling stand, and many others. The problem is this: if the gauge of the material coming out of the mill is not right, which of the many possible controlled variables should be changed, and by how much?

The answer can often be calculated if the quality of the output and the value of all input variables are known, but the calculations are quite complicated and time-consuming. For this reason, digital computers are being used today as controlling elements in continuous-process lines.

Certainly in many of these complex processes, the

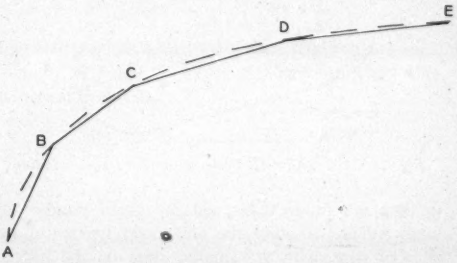


Fig. 7. Series of straight lines, approximating a curve, would be milled if ratios set into binary multiplier coupled to milling machine are continually changed

control of speeds and speed ratios is very important. The digital elements used in the system described here, particularly the error register and the binary multiplier, are elements commonly used in digital computers and lend themselves well to the computation and generation of complex functions. Thus, this system is only a step away from true computer control of continuous-process lines.

HARRY G. PARKE and URSULA T. PARKE

Minimum-resistance coil design

Significant reduction of coil resistance is possible through use of a divided-winding technique. Since the two portions of the winding have equal resistance and the same number of turns, they may be connected in parallel as well as in series

One of the most frequent problems in electrical engineering is the design of a coil to produce a magnetic field within a pole. The device may be a relay, a field coil, a holding magnet, a transformer, or an inductor. In general, the flux through the pole is the desired result; the power dissipated in the resistance of the coil is the price that must be paid. For some applications, such as relays, high-frequency transformers and ferrite-core inductors, efficient design leads to a coil with an outer diameter large compared to the pole diameter. In such cases it is possible

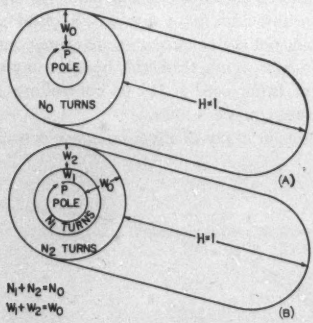


Fig. 1. Coils with (A) 1-part and (B) 2-part winding

to obtain a lower resistance per given number of turns by constructing the coil from two or more sizes of wire, with the smaller sizes on the inside, than by winding it with wire of one size. The improvement is generally not large but is often significant; there are substantial fringe benefits, and the added cost and complication are slight.

To avoid introducing symbols that will vanish in the final results we will assume the coil to be wound of material of resistivity equal to one. Further we will assume that the coil length is unity and that the winding consists of flat conductors, each turn extending the full length of the coil. This is actually a practical method of construction (foil wound coils), but the results to be derived apply equally well to coils wound conventionally of round or square wire, provided the same space factor is maintained.

Fig. 1(A) shows a coil wound as described, consisting of n_0 turns of constant thickness foil, wound out to a distance w_0 from the perimeter. The cross-sectional area of the foil is, therefore, w_0/n_0. Let p be the perimeter of the pole. If the pole is everywhere convex the length of a turn a distance w from the pole surface will be $p + 2\pi w$ and the mean turn length will be $p + \pi w_0$.

The resistance of the winding will therefore be

$$R_1 = n_0 (p + \pi w_0) \frac{n_0}{w_0} = n_0^2 \left(\frac{p}{w_0} + \pi \right) \qquad (1)$$

Defining $\rho = p/w_0$ this becomes

$$R_1 = n_0^2 (\rho + \pi) \qquad (2)$$

Consider now the situation shown in Fig. 1(B). The same pole is now assumed to be wound to a height w_1, with n_1 turns of foil, and above that wound to a height w_2 with n_2 turns of a foil of different thickness. We assume $w_1 + w_2 = w_0$ and $n_1 + n_2 = n_0$. Applying equation 1 successively to the two portions of the winding we obtain

$$R_2 = n_1^2 \left(\frac{p}{w_1} + \pi \right) + n_2^2 \left(\frac{p + 2\pi w_1}{w_2} + \pi \right) \qquad (3)$$

Let $\nu = n_1/n_0$, and $\omega = w_1/w_0$. Then equation 3 may be written

$$R_2 = n_0^2 \left[\frac{\nu^2 \rho}{\omega} + \nu^2 \pi + (1 - \nu)^2 \left(\frac{\rho + 2\pi\omega}{1 - \omega} + \pi \right) \right] \qquad (4)$$

If ω is assumed constant, equation 4 may be differentiated with respect to ν and $dR_2/d\nu$ set equal to zero. The result will give the optimum value for ν

$$\nu_{opt} = \frac{\omega (\rho + \pi + \pi\omega)}{\rho + 2\pi\omega} \qquad (5)$$

A special article recommended by the AIEE Relays and Transformers Committees.

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Alternatively ν may be assumed constant and equation 4 may be differentiated with respect to ω. Setting $dR_2/d\omega$ equal to zero gives the following requirement for optimum ω:

$$\frac{\omega_{opt}}{1-\omega_{opt}} = \frac{\nu}{1-\nu}\sqrt{\frac{\rho}{\rho+2\pi}} \tag{6}$$

for the best possible winding (R_2 an absolute minimum), equations 5 and 6 must both hold. Solving them simultaneously yields

$$\nu' = \frac{1}{2} \tag{7a}$$

$$\omega' = \frac{-\rho+\sqrt{\rho^2+2\pi\rho}}{2\pi} \tag{7b}$$

Equation 7b is plotted in Fig. 2 as a function of ρ/π. It will be noted that for coils of small build (large ρ) ω' approaches ½, while for coils of large build (small ρ) ω' approaches zero.

Substituting the values of ν' and ω' for ν and ω in equation 4 yields

$$R_2' = \frac{n^2\pi^2}{2}\left(\frac{1}{\pi+\rho+\sqrt{\rho^2+2\pi\rho}}\right) \tag{8}$$

Half of this resistance is in the inner portion of the coil and half in the outer. Thus, the minimum resistance 2-part winding has half the resistance and half of the turns in each section.

Dividing R_2' by R_1 indicates the improvement obtained.

$$\zeta_2 = \frac{R_2'}{R_1} = \frac{\pi^2}{2(\pi+\rho)(\pi+\rho-\sqrt{\rho^2+2\pi\rho})} \tag{9}$$

Equation 9 is plotted in Fig. 3 as a function of ρ/π. It will be noted that for $\rho/\pi \leqq 1$ (coil build equal to or greater than pole diameter for circular coils) substantial reduction of the resistance is achieved.

Evidently a further reduction of resistance would be possible by dividing the winding into more than two parts. It would be possible to repeat the preceding tactics for a 3-, 4-, or n-part winding. The ultimate would be to have the winding divided into an infinite number of parts. If we start with a uniform winding, optimally divide it into two parts, optimally divide each part into two parts, and so forth, we would approach a winding with a uniform resistance increase for each turn increment. Such a winding would consist of a variable-thickness foil winding. If it is wound around the same pole with the same number of turns and to the same build as before, the foil thickness, as a function of winding angle θ, is given by

$$t = \frac{\rho}{2\pi n_0}\left[\ln\left(1+\frac{2\pi}{\rho}\right)\right]\left(1+\frac{2\pi}{\rho}\right)^{\frac{\theta}{2\pi n_0}} \tag{10}$$

A winding of this type has a resistance

$$R_\infty' = \frac{2\pi n_0^2}{\ln\left(1+\frac{2\pi}{\rho}\right)} \tag{11}$$

Dividing R_∞' by R_1 yields the maximum possible reduction in resistance:

$$\zeta_\infty = \frac{R_\infty'}{R_1} = \frac{2\pi}{(\rho+\pi)\ln\left(1+\frac{2\pi}{\rho}\right)} \tag{12}$$

Equation 12 is also plotted in Fig. 3. It will be noted that the advantage of the continuously graded winding over the 2-part winding is small except for coils of very large build.

The advantages of the divided-winding technique are:

1. Significant reduction of coil resistance is possible for coils of large build.
2. Since each portion of the winding has equal resistance and equal turns, the portions may be connected in parallel as easily as in series.
3. For the same reason, the construction is particularly adaptable to center-tapped windings on transformers and differential winding of relays.

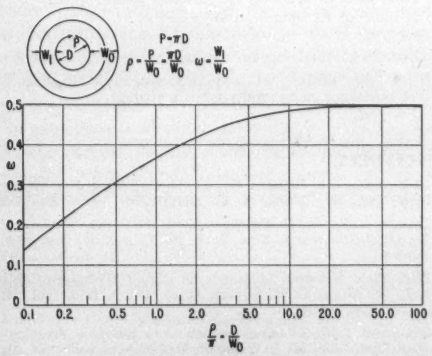

Fig. 2. Optimum proportions for 2-part winding

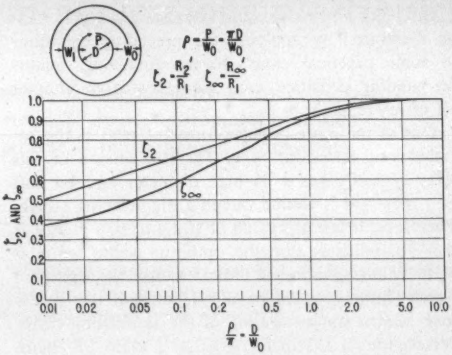

Fig. 3. Resistance reduction with optimum 2-part winding and with uniformly graded winding

The limitations are:

1. Increased heat generation occurs in the inner turns, where heat dissipation is usually more difficult.

2. The restricted range of wire sizes readily available may prevent full realization of the theoretical advantages.

Both the advantages and disadvantages may best be illustrated by applying the preceding equations to some practical cases. In the following, figures on winding densities, etc., are taken from chapter VI of reference 1:

One of the more popular forms of relay is the so-called long telephone type. The d-c version of this relay typically has a ⅜-inch diameter circular soft iron core and is wound out to a diameter of 1 inch. Therefore, it has a ρ value of equal to $6/5\ \pi$. Equation 7b indicates that the optimum value for ω is 0.38, while equation 9 indicates that the optimum 2-part winding would have 5.3 per cent less resistance than a single winding of the same total turns.

Assuming a 2⅝-inch coil length and no. 38 enameled magnet wire, which has a turns density of 49,400 turns per square inch, a single-part winding could be wound of 40,500 turns. Such a winding would have a length of 87,400 inches, and therefore a resistance at 20 C of 4,800 ohms.

For an ideal 2-part winding, the turns density of the inner winding should be $49{,}400 \times (0.5/0.38) = 65{,}000$ turns per square inch. No standard AWG wire has this value, no. 39 being the closest at 61,200. The use of 20,250 turns of no. 39 yields a w_1 of 0.126 inch, so $\omega = 0.404$ instead of the optimum 0.38. The resistance of this inner winding will be 2,210 ohms. There is left a cross-sectional area of 0.49 square inch, so a wire having a turns density of 41,400 turns per square inch would be ideal. The closest available is no. 37 at 39,800, so 19,500 turns could be in this winding. This outer winding would have a resistance of 2,170 ohms. Thus, the 2-part winding will have a total of 39,750 turns and a resistance of 4,380 ohms, or 98.2 per cent of the number of turns and 91.2 per cent of the resistance of the 1-part winding. The power required for a given flux in the pole is proportional to n^2/R, and for the 2-part winding is 0.947 of that for the 1-part winding. Thus, despite the deviations from the optimum winding, substantially all of the theoretical improvement in sensitivity can be obtained.

In an inductor the reduced resistance is reflected in higher Q. In a transformer, of course, the increased inductance and decreased resistance could be translated into improved low-frequency response and decreased copper losses. A convenient way to design a 2-winding transformer on such a core is to have one winding extend to ω' of the build with the other winding wound above it. The primary and secondary copper losses would be equal, insuring maximum efficiency.

A final example concerns ultrahigh field magnets, used in nuclear and spectroscopic research. The "classical" design in this field, that of Bitter,[2] uses a single-layer edge-wound helix. Since such a construction has radial lines for equipotentials the current density decreases inversely as the radius, exactly as it would with the optimal uniformly graded winding. It therefore has the same resistance as an optimum uniformly graded winding of the same number of turns and same volume. Probably for ease of fabrication[3] or definiteness of field[4] some more recent designs use flat wound strap[3] or rectangular wire.[4]

The design of Giauque and Lyon[4] uses a coil of 4.02 inches ID and 15.34 inches OD. It therefore has a ρ of $0.71\ \pi$. From equation 12, for this ρ, $\zeta_\infty = 0.873$. Therefore a 14.5 per cent increase in resistance is the price paid for departing from the design of Bitter. For $\rho = 0.71\ \pi$, $\zeta_2 = 0.911$, so a reduction in resistance of 8.9 per cent would be possible with a 2-part winding.

The design of Adair, Squire, and Utley,[3] is liquid nitrogen cooled, and has an ID of 2 inches and a build of 3.77 inches; therefore it has a ρ of $0.53\ \pi$, for which $\zeta_\infty = 0.836$. Thus the coil's resistance is 19.6 per cent higher than that of a Bitter coil of the same over-all dimensions. A 2-part winding would yield a ζ_2 of 0.881 and again a closer approximation to the optimum uniformly graded winding seems to be needed.

NOMENCLATURE

p = perimeter of inner pole
w_0 = winding depth of 1-part winding
w_1 = winding depth of inner section of 2-part winding
w_2 = winding depth of outer section of 2-part winding
$\omega = w_1/w_0 = w_1/(w_1+w_2)$
n_0 = number of turns of 1-part winding
n_1 = number of turns of inner section of 2-part winding
n_2 = number of turns of outer section of 2-part winding
$\nu = n_1/n_0 = n_1/(n_1+n_2)$
R_1 = resistance of 1-part winding
R_2 = resistance of 2-part winding
ω_{opt} = value of ω to produce minimum R_2 for given ν
ν_{opt} = value of ν to produce minimum R_2 for given ω
ω', ν' = values of ω and ν for absolute minimum R_2
R_2' = value of R_2 when $\omega = \omega'$, $\nu = \nu'$
$\zeta_2 = R_2'/R_1$
t = (variable) thickness of continuously graded winding
θ = winding angle
R_∞' = resistance of optimally graded winding
$\zeta_\infty = R_\infty'/R_1$

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J. M. COFFIN and L. B. JOHNSON

A stitched-wiring process for miniaturized communications electronics

A recently developed manufacturing process known as stitched wiring permits economical fabrication of circuits by automatic or semiautomatic methods The technique is now being used in the manufacture of multichannel telephone and telegraph carrier equipment

With the advent of transistors and similar solid-state components, an investigation was undertaken of the feasibility of using printed or etched circuit boards in telephone-type multichannel carrier equipment. The result of this study was the development of the manufacturing process here described. It permits automatic or semiautomatic fabrication, and maintains excellent standards of reliability in the finished product. It offers a degree of repairability comparable to more conventional wiring.

The stitched-wiring process, as it is called, has proved to be more economical for the Lenkurt Electric Company than fabrication by other methods. Although no attempt has been made to meet military specifications with these stitched circuit boards, individual pieces and processes—for instance, the gold-plating on connector pins—do meet MIL specifications. Fig. 1 shows typical circuit boards fabricated by the stitched-wiring technique. Large components may be accommodated by spacing two or more boards apart on a modular basis.

THE PROCESS

An insulating board is used, as in printed or etched wiring. The basic board is black *XP* phenolic—the same material that is used for conventional hand-wired boards. It is manufactured by usual sheet metal shop methods. Boards are sheared or blanked to size. Common holes are punched or drilled and, at this point, the boards may be stocked as basic inventory for the stitched-wiring process.

The process dispenses with laminated copper foil for the wiring, and substitutes tin-coated bronze staples and "automatic hand wiring" at appropriate locations. Each staple becomes the termination for one or more nearby components, and for bare-wire connections to other terminations of this type. As in printed wiring, all components are located on one side of the board, and wiring and interconnections are located on the other side. All component leads and connecting wires are wrapped firmly around the

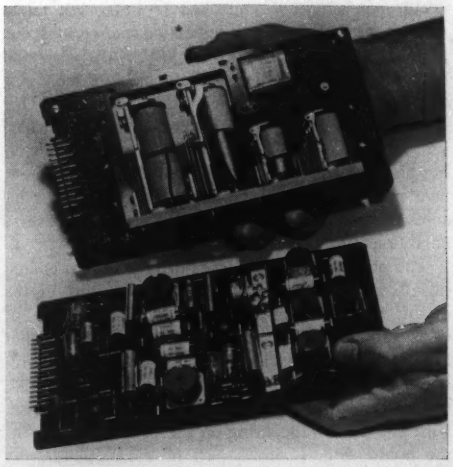

Fig. 1. Typical stitched-wiring circuit boards

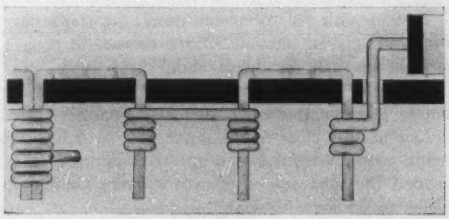

Fig. 2. The stitched-wiring principle illustrated

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staple legs, thus providing excellent mechanical and electrical connections before soldering. Fig. 2 is a schematic representation of the principle. Unlike conventional printed-circuit assemblies, the solder is not used to strengthen the mechanical joint between components and connecting wire. The staples are driven through the board without prepunching. Component leads pass through adjacent holes and wrap around staple posts. Staples are interconnected with bare-wire straps and the entire underside of the board is dip soldered.

As many components as possible are selected or designed to have stiff leads or posts, instead of flexible leads. For instance, a transformer may have five stiff posts projecting from the bottom of the case, similar to the pins of a vacuum tube. These posts serve as terminals and also provide means for attaching the transformer to the board. All components are mounted on the board and wired complete, entirely independent of the metal mechanics.

The stitched-wiring process begins with the attachment of male connector pins to the edge of the board (if the board is a plug-in unit). These connector pins are preforms of two different sizes which, when crimped and locked into place, form an even row of contacts. The insertable portion of the connector pin is closely controlled to 1/16-inch thickness to meet the same specifications as commercial prefabricated male connectors. Within the edge and perpendicular to the face of the board, a double row of connector posts is formed, standing about 3/16-inch high. A section of such a connector is shown in Fig. 3. After they are inserted in the board, connecting pins are treated in the same manner as component mounting staples. Gold plating on the pins insures the maintenance of good contact under adverse conditions.

The next operation involves driving the tin-coated bronze staples at precise, discrete positions in the board, thus creating staple posts. The location of each staple post represents the termination of either a component lead, a bare-wire strap, or (infrequently) a long, insulated crossover or jumper. All staples pass through the board in the same direction, with the crowns appearing on the component side of the board. Fig. 4 shows part of the staple-driving machine. An anvil beneath retracts downward to permit board to be moved horizontally to next location. No prepunching for the staples is required.

Just as with the connector posts, the staple legs are not clinched, but instead are allowed to project straight through the board about 3/16 inch. Near each staple post are located holes through which one or more component leads may be passed. Holes are sufficiently close to the staple post so that automatic wrapping guns can wrap the component leads around the adjacent posts in a manner similar to Keller or similar wire-wrapping guns.

After the staples and connectors have been added,

Fig. 3. Close-up of preformed male connector pins

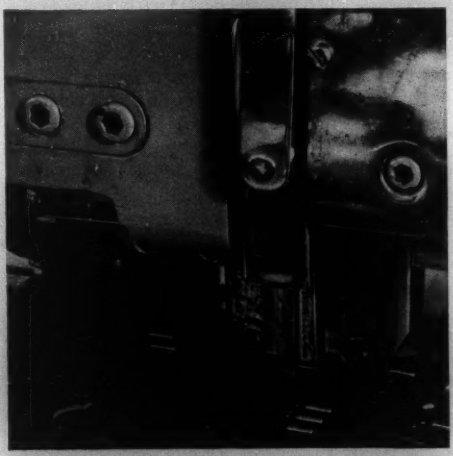


Fig. 4. Close-up of stitching staple driving head

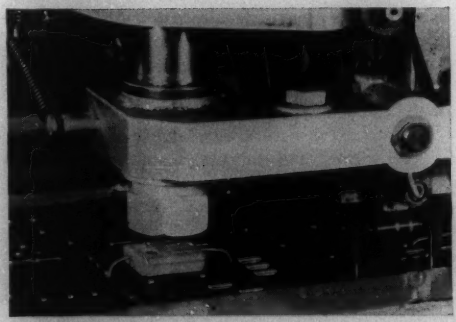


Fig. 5. Automatic component insertion head on the line at the first station, showing resistor half inserted

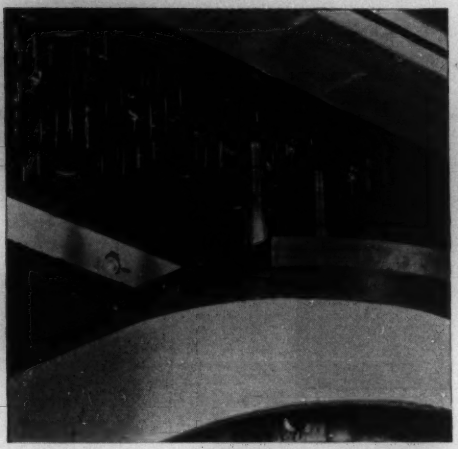


Fig. 6. Wrapping head, wrapping the leads of a component around adjacent staples

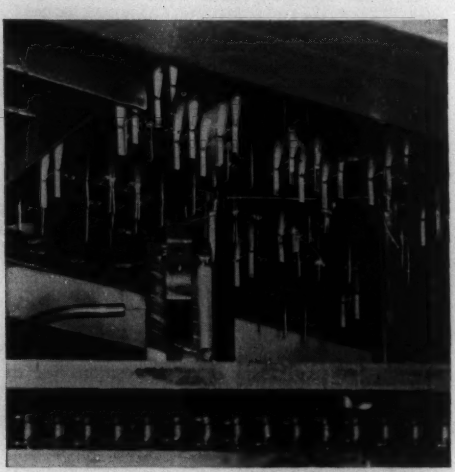


Fig. 7. Typical strapping head

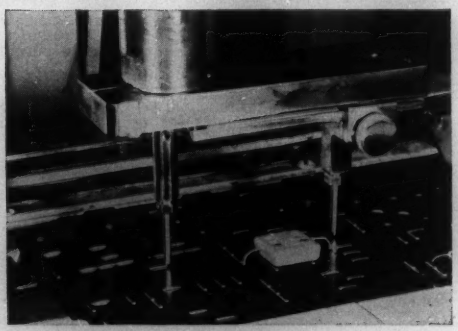


Fig. 8. Automatic fingers which hold board during strapping

the board corresponds roughly to a printed circuit board which has been etched and drilled, but which is still without components. In the stitched-wiring process, components may be inserted automatically, using standard component insertion heads (Fig. 5), or they may be inserted manually. Two special pieces of equipment are used at the component insertion stations:

1. An automatic head containing two wire-wrapping bits of the end-loading type, which automatically rise into position and simultaneously wrap the two component leads around adjacent staple posts. Fig. 6 shows a wrapping head in position beneath a stapled board. The same head is used at the manual stations, and for the full range of component sizes. The bits retract after wrapping to permit the conveyor to advance.

2. An automatic head containing two side-loading wire-wrapping bits and a spool of bare wire. The bits rise into position, when the conveyer is in dwell, and automatically strap a piece of bare wire across any two staple or connector posts, then cut the spool wire free. The heads reload themselves with wire for the next board during the time the conveyor is in motion. Fig. 7 shows a typical strapping head. Strapping bits rise, carrying a length of bare wire, and wrap both ends around two staple posts to be strapped together. Rotation is equal and opposite. The cycle is fully automatic.

Both of these heads are self-sequencing, but are given a starting signal by the conveyor itself. When the board is in position, both types of head rise to the bottom of the board so that the staple or connector posts enter the center holes of the wrapping or strapping bit. When the operation is completed, a matter of approximately half a second, the bits retract so that the conveyor can advance to the next station. The strapping stations are unattended, and the only equipment installed above the conveyor line at these points is a pressure pad (shown in Fig. 8) which moves into place and holds the board flat as the heads are operating. An automatic set of holding fingers can be adjusted to fit any board and any length of strap so that two steel fingers are directly above strapping bits.

Thus, a stitched-wiring assembly line not only is a component insertion line, as it would be with printed circuits, but also provides the interconnections necessary between components.

The basic stitched-wiring machinery, shown in Fig. 9, is a General Mills Auto-fab conveyor line, originally designed for the automatic insertion of components in printed circuit boards, and modified to provide the following features:

1. An operator may sit at any position along the conveyor with comfort.

2. Wrapping and strapping stations installed under the conveyor are as easily set up and put into proper

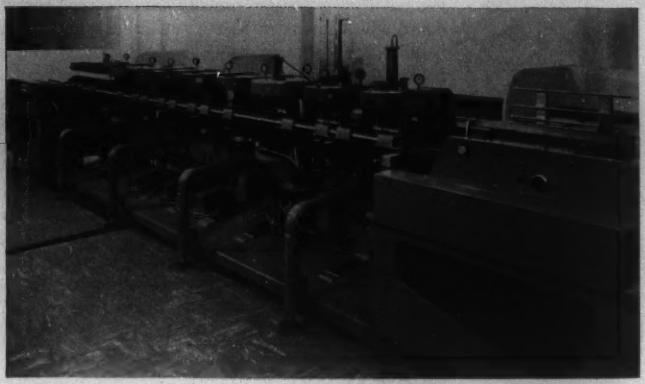


Fig. 9. General view of combination strapping and component insertion line

positions as the insertion heads themselves. A pancake design provides adequate clearance above an operator's knees.

3. The frame of an insertion head can be used to hold and actuate the pressure pad required at the strapping stations.

4. Automatic insertion is attained with the same heads that would be used for printed circuits, except that a slight modification is required to provide a longer lead length. The wrapping stations replace the anvils originally used to clinch the leads on a printed circuit board.

5. Setup is sufficiently fast that multiple-pass operations are economical.

The same type of soldering station is used as would be used with a printed circuit board. The bottom side of the board exposes only staple posts, bare wire straps, and the ends of the component leads. Passing the board through a soldering station adequately solders all connections.

Unlike printed circuits, these boards can be tested before soldering, since good mechanical and electrical connection of all wire and leads is provided. Test fixtures can be made which use the staple posts as connectors.

In passing the board through the soldering station, no great care is necessary to avoid jiggling or vibration. Each mechanical connection is very tight and provides almost perfect dimensions for capillary attraction of the solder into the spaces between the wrapped wire and the posts themselves.

Automatic and semiautomatic machinery are not required to manufacture these boards; they can be completely built up by hand. Field repair is simple, and no more than ordinary hand tools and a soldering iron are required to replace any defective component on a board.

FEATURES AND ADVANTAGES

Stitched wiring is surveyed below on the basis of mechanical, electrical, and economic considerations:

1. Stitched-wiring base material is inexpensive.
   a. *XP* or *PC* phenolic versus *XXXP*.
   b. It is not copper-faced.

2. Holes for component leads are punched in plain base material without the problems that prevail when a composite material is used.

3. A stitched-wiring board is ready to "assemble" when the holes have been punched and connectors and staples driven.
   a. It may be assembled automatically.
   b. It may be assembled semiautomatically.
   c. It may be assembled by hand.

4. The board may be tested completely before soldering. For automatic testing, the staple posts act as connector pins and may be plugged into a test jig.

5. Automatic soldering is the same in any case, but with the stitched-wiring method there is the least copper dilution in the solder pot.

6. For short runs, the start-up cost is low; there is only the variable of the discrete positions for the staples. Two templates are required for each board at about $55 each. Without a programmable drilling machine, a drill jig will be needed.

In terms of capital equipment investment, the minimum equipment absolutely required for the stitched board is as follows:

1. Standard drill press.

2. Drill jig for each board, constructed to permit drilling 8 to 10 boards at one time; cost approximately $160.

3. Two stapling templates for each board; total cost approximately $110.

4. The stapling machine, which could be simpler for very short runs, costing as follows:

Wales duplicator attachment	$1,500
Special mounting base	4,500
Acme stitching head	1,000
Assembly and alignment labor	1,000
TOTAL	$9,000

From this point on, additional equipment accom-

Table I • ESTIMATED FACTORY COST OF STITCHED WIRING BOARDS (Small to Medium Quantities)

Material	
5- by 8-inch board	$0.1240
8-pin connector	0.0872
Staples, wire (67)	0.1340
Guide clips (2)	0.0156
Total Material Cost	$0.3608
Labor, hours	
Shear	0.0195
Punch	0.0040
	0.0072
	0.0016
Silk screen, designations	0.0110
Neutralize, wash	0.0024
Drill (132 vs. 76)	0.0528
Stitch (67)	0.0536
Install connector (8)	0.0216
Clean	0.0024
Guide clips	0.0117
Bare wire straps (12)	0.0071
Total Labor Hours	0.1949
Labor Dollars at $2.00 per hour	$0.3898
Burden Dollars at 165 per cent	0.6432
Manufacturing Cost (Material, Labor, and Burden)	1.394
Reject and Rework Cost at 1 per cent	0.014
Cost of Board Ready for Components	$1.408

From here on, cost of component insertion and dip soldering can better be computed by the reader, who knows what components he uses and may already have a soldering machine.

plishes cost reduction only. Lenkurt of Canada has built a simpler machine for short runs which might cost $3,000 in the United States. Substantially, the following are nearly identical for all processes used in manufacturing circuit boards: component preparation; component insertion; automatic fluxing and soldering; hole drilling or punching; and designation marking.

For the stitched board, the following items appear to be cheaper than for any other method: base material, including staple wire; processing chemicals, which are not required for stitched boards; amount of solder and flux; drafting time for initial layout; time to repair a defect (rework); and in-process reject rate.

In terms of board quality, a stitched board is obviously superior mechanically, and possesses high electrical quality too, in that

1. Conductors are not in intimate contact with the board. Therefore, moisture absorption has almost no effect on the Q of the board.
2. Distributed capacitance is low.

From a board design point of view:

1. Crossovers are easily attained, yielding the advantages of a double-side etched board.
2. Strapping options are easily attained.
3. Slightly dissimilar boards require no extra tools; options are inherently available in the drill jigs and templates.
4. No component is made obsolete by a change in circuit design; the tools and set-ups are easily changed. Thus, board designers have considerable freedom.

A minor disadvantage of the stitched-wiring process is that staples may not be driven too close to the edge of the board.

COST REDUCTION

Within the series of steps which may be taken to reduce costs, some steps produce a much higher economic return than others. For instance, automatic soldering provides the highest return of all, automatic component insertion the lowest, etc. On the other hand, the combination of manual insertion (on the conveyor line) and automatic wire wrap has a very high return, and it is in this area of part automation and part manual operation that the highest return is earned with small and medium quantities. Complete automation is feasible for very large quantities with commensurate cost reduction.

COST COMPARISON

There is no satisfactory manner by which the cost of a stitched-wiring board can be compared with a printed circuit board. Finished boards with all components assembled and soldered and the circuit tested should be compared as finished products, but quantities, economical lot sizes, labor rates, product mix, capital investment, and original development costs would become involved, resulting in calculations beyond the scope of this article. Therefore, costs have been collected and are presented as the best estimate now available for an average cost in the United States for producing stitched-wiring circuit boards in small to medium quantities; see Table I.

CONCLUSION

The stitched-wiring technique is now being used in the manufacture of multichannel telephone and telegraph carrier equipment and various supporting types of communication equipment. Substantial manufacturing economies have been realized, and long-term observation of this equipment confirms that reliability and serviceability are excellent.

230-KV SHUNT REACTOR

A 25,000-kva 230-kv shunt reactor, said to be the largest in the United States, was recently shipped by the Westinghouse Electric Corporation to Arizona Public Service for use in their Cholla Steam-Electric Plant near Holbrook, Ariz. The reactor has been connected near the mid-point of the new 300-mile 345-kv transmission line through a 345/220-kv autotransformer to compensate for the capacitive charging reactance of the high-voltage lines.

R. E. GRAHAM and C. R. BOND

Radio-influence testing on 70 miles of 345-kv horizontal bundle conductor

A satisfactory radio-influence level (RIL) can be achieved in a 345-kv transmission line using 945-MCM ACSR conductor bundled at 18-inch spacing, standard clamps, triangular space plates, and a horizontal phase spacing of 27 feet. Attenuation tests show that RI readings at one site are not materially affected by precipitation on the line a few miles away

The Ohio Edison Company conducted laboratory tests (previous to the construction of 70 miles of the 345-kv line) to determine the corona and RI levels of the line hardware to be used on its 345-kv transmission lines and has conducted field tests on the completed transmission line to evaluate the selection of hardware. On January 31, 1961, the Sammis-Star North 345-kv transmission line was energized for RI testing; see Figs. 1 and 2. The tests ran for approximately 8 weeks.

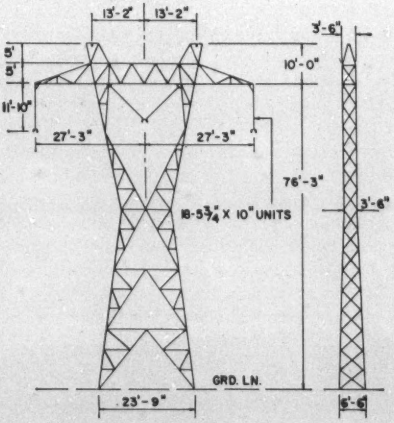
LABORATORY TESTS

In 1958, the company conducted laboratory tests on various types of hardware and conductors for corona and RI, the results of which are shown in Table I (all voltages are line-to-ground). This test data provided the basis for the selection of the hardware assembly for the 345-kv transmission lines.

A comparison of laboratory data of "cleaned" and "as received" conductor corona and RI tests indicated that a significant reduction in RI could be expected with the use of tension stringing; it was therefore adopted. The "as received" condition is similar to that of conductors strung in a normal manner.

Because of differences between laboratory and field work, it was decided to conduct RI field tests on the Sammis-Star North 345-kv transmission line. These tests were to evaluate further the laboratory tests.

Laboratory tests had indicated that control rings might not be necessary on conductor hardware assemblies and, since RI field tests were necessary to substantiate the laboratory results, it was decided to construct the Sammis-Star North 345-kv transmission line without control rings on the 26-mile section at the plant end, and with control rings on the remaining 44 miles of line.



TOWER WEIGHT APPROX. 3.3 TONS
MAXIMUM VOLTAGE 363 KV
CONDUCTORS - BUNDLED 954 MCM 48/7 ACSR - 18" SPACING
GROUND WIRE 159 MCM 12/7 ACSR
MAXIMUM TENSION
CONDUCTOR 10,000#/COND.
20,000#/BUNDLE
GROUND WIRE 7,000#
MINIMUM GROUND CLEARANCE
35 FT. @ 120° F.
MAXIMUM TANGENT SPAN - GRADE - C (NESC)
1000 FT.

Fig. 1. Tangent tower type 3A

Essentially full text of paper 61-1027, recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Detroit, Mich., Oct. 15-20, 1961. Scheduled for publication in AIEE *Communication and Electronics*, 1961.

R. E. Graham and C. R. Bond, Associate Members AIEE, are with the Ohio Edison Company, Akron, Ohio.

The authors express their thanks to members of the Ohio Edison Company who aided in all phases of the testing; and to Commonwealth Associates, Inc., of Jackson, Mich., the Ohio Brass Company, and the Westinghouse Electric Corporation for their advice and assistance.

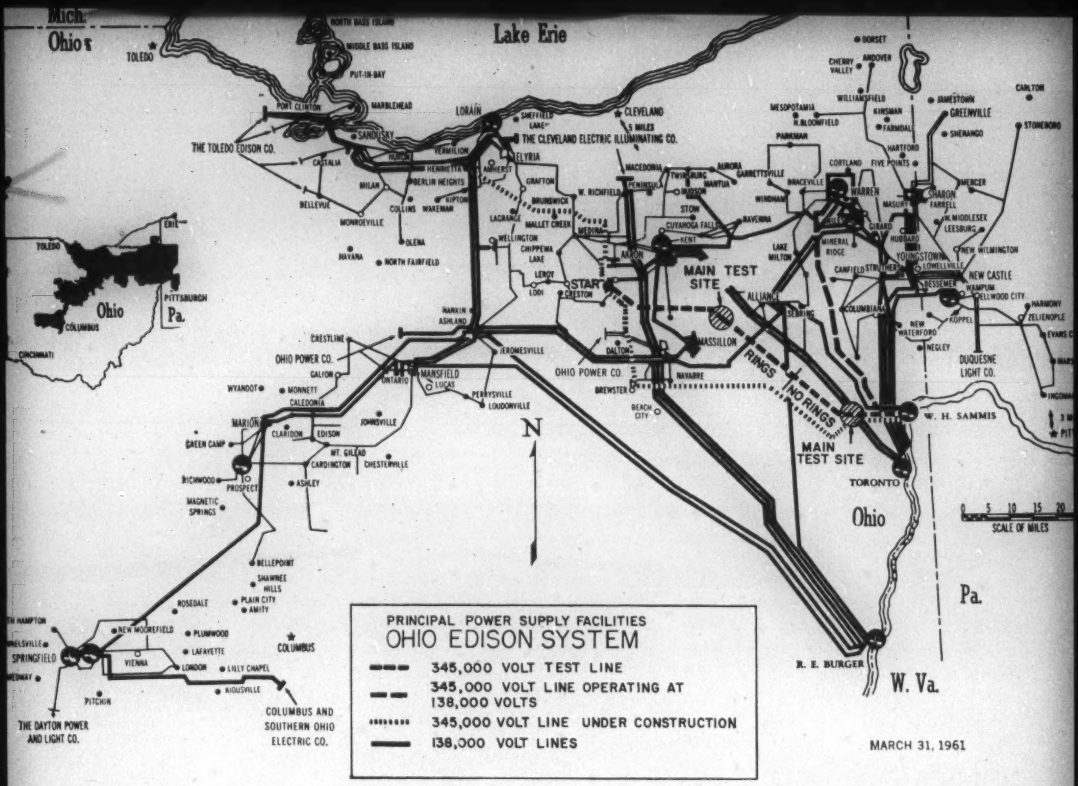


Fig. 2. Ohio Edison system

AMBIENT LEVEL TESTS

Prior to and during the construction of the 345-kv transmission line, ambient noise level readings were taken along the right of way to establish an ambient level for the area and for some of the existing lines crossed by the 345-kv line. The normal ambient level ran from about 5 to 10 microvolts per meter as read on the "quasi-peak" scale of a Stoddart *NM 20B* meter with an effective ½-meter rod antenna. Tests were conducted on other lines throughout the system to gain a better knowledge of acceptable levels of RI and the methods of measurement.

345-KV LONG-LINE TESTS

Preliminary Work. Two sites were selected as the primary test locations, one in the center of the 26-mile section of line without control rings, the other in the 44-mile section with control rings, 13 miles from where the rings start. The sites were nearly identical in all respects and thus eliminated some of the possible variables.

The two sites were staked so that all lateral and longitudinal readings would be taken at exactly the same location regardless of the number of readings. Lateral stakes were placed 25 feet apart for 300 feet either side of the center line while the longitudinal stakes were 20 feet apart, 75 feet either side of the centerline for about 600 feet. The transmission line was energized at the Sammis Plant at 345 kv and open-ended at the Star Substation 70 miles away.

Test Procedure and Instrumentation. Frequency runs and longitudinal readings were made at both primary test sites to determine if standing waves existed; none were found. The tests were repeated periodically during the test period and proved that standing waves were not present.

For the normal daily tests lateral measurements were made at each site at approximately the same time, which made possible a comparison of the two sites during fair weather.

To minimize possible differences in meters, they were never used at the same site on two successive days and each meter was read by the same person throughout the tests. Daily readings were taken throughout the test period so that comparisons of the two sites might be made in all kinds of weather.

Lateral readings were taken until an attenuation pattern was established; then the readings were limited to half laterals and readings taken at one point on the lateral profile generally 100 feet diagonally from the outside conductor.

TABLE I • LABORATORY CORONA AND RIV TEST RESULTS

Test Number	Conductor			Supporting Structure		RIV Values				Remarks
	Description	Fittings	Surface Condition	Insulators	Connection between Insulators and Conductor	Corona Voltage	Kilovolts for 100 Mv	Kilovolts for 1,000 Mv	M Volts at 200 Kv	
1		none	as received	none	none	210	265	300	0	
2		none	cleaned	none	none	275	280	292	0	
3		articulated spacer	cleaned	none	none	240	255	262	0	
4		coiled spring spacer	cleaned	none	none	263	268	272	0	
5		Unibal spacer	cleaned	none	none	206	277	295	0	
6		preformed spacer	cleaned	none	none	254	255	300	0	
7		Austin spacer	cleaned	none	none	257	267	277	0	
8		standard preformed armor rods	cleaned	none	none	220	222	230	0	
9	954 MCM 48/7, ACSR, 1.175-inch diameter.	standard preformed armor rods with corona shields	cleaned	none	none	327	290	320	0	
10	Horizontal 2-conductor bundle	parrot-billed preformed armor rods	cleaned	none	none	255	264	271	0	
11	18-inch spacing	parrot-billed preformed armor rods with one rod extending 1-inch	cleaned	none	none	239	247	258	0	
12		tapered armor rods with spherical corona clamps	cleaned	none	none	300	290	302	0	
13		preformed armor rods with corona end shields	cleaned		suspension clamps	200	200	275	100	simulated 345-kv bundle assembly
14		preformed armor rods with corona end shields	cleaned	One 18-unit string of 10-inch suspension insulators	suspension clamps and corona rings	325	265	330	0	simulated 345-kv bundle assembly
15		preformed armor rods with corona end shields	cleaned		armor grip suspension unit	160	210	265	50	simulated 345-kv bundle assembly
16		none	cleaned		reaction lever clamps	243	290	296	15	simulated 345-kv bundle assembly
17	266.8 MCM ACSR	preformed armor rods	as received	10-10-inch disks	suspension clamp	70	115	124	18,000	138-kv suspension assembly
18	795 MCM ACSR	preformed armor rods	as received	16-10-inch disks	suspension clamp	132	140	173	16,000	230-kv suspension assembly

The two Stoddart meters, an *NM 20A* and an *NM 20B*, were calibrated prior to the testing and several times during the test period and found to be very stable. The meter readings were taken with an effective ½-meter antenna at 1.2 mc since this frequency was the only reliable frequency near 1 mc.

Comparison of the Two Sites. The curves in Fig. 3 show a comparison of the two main test sites in fair weather and during heavy precipitation. The results of fair weather tests show the test site with control rings has an RIL approximately the same as the test site without control rings. Daily readings at both sites continually show the results at the site without control rings as slightly lower than the site with rings, which is further proof that control rings are of little or no value in suppressing RI on bundle conductors. The shielding effect of bundle conductors is possibly sufficient to nullify the effect of the control rings.

The lateral attenuation curves taken during heavy precipitation show the results at the two main test sites to be in close agreement. The site without control rings has the high RIL but this is because an unequal number of readings were compared and because of the variability of weather conditions. If sufficient data were taken it is felt that the site without rings would have a slightly lower radio-influence level than the site with control rings since, normally, when both sites experienced the same apparent heavy precipitation, the site without control rings showed results slightly lower than that with control rings.

The highest RIL under the conductors was recorded at each site on the same day during a heavy, wet snow storm. The site with control rings recorded 77 db above 1 microvolt per meter while the site without control rings recorded 73 db above 1 microvolt per meter level. The high readings were obtained early in the test period and the levels associated with heavy precipitation continued to attenuate throughout the test period. The minimum level recorded at any time under the conductors at

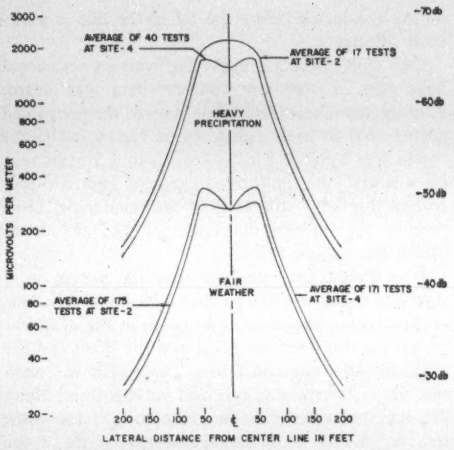


Fig. 3. Lateral reading at site 4 with control rings and site 2 without control rings in heavy precipitation and fair weather

both test sites was approximately 44 db above 1 microvolt per meter.

The curves in Fig. 3 show a dip at the center line in fair and foul weather for the test site with control rings while the test site without control rings has little or no dip. An examination of the relative physical position of the phases relative to the ground and each other showed no apparent difference between the two sites. Possibly the presence of the dip indicates the center phase has less RI than the outside phases while no dip indicates the same apparent level on all three phases.

Because radio stations saturated the broadcast band, RI readings at night were very difficult and at times impossible to make.

RI readings and night photographs (Fig. 4) of conductor hardware assemblies, with and without corona present, were made on several occasions in an effort to study the effects of conductor hardware assembly corona on the RI level of the line. Although the data are not considered conclusive, there is an indication that possibly the conductor hardware assembly is never a primary source of RI.

Time exposure night photographs (Fig. 4) show that the conductors are not in corona except during precipitation such as rain or snow. The conductors are the primary source of RI in foul weather, overriding all other sources with levels about 10 times the fair-weather influence readings.

During fair weather, the conductors have no audible corona except for possibly isolated instances; also the insulator and hardware assemblies are generally quiet.

For fair weather tests the voltage was raised slightly above the nominal operating range and the line was satisfactory, with RILs very similar to those at 345 kv.

When the voltage was dropped slightly below 345 kv, but still within the nominal operating voltage range, measuring any RI was impossible and it was necessary to check to see if the line had been for some reason de-energized. This indicates that the line has an RI start voltage in the nominal voltage range during fair weather.

In 1962, when the Sammis-Star North and the new Sammis-Star South 345-kv lines are put into operation at 345 kv, it will be possible to evaluate the designs further.

MISCELLANEOUS TESTS

Daily Burn-Off. During the first part of the testing, the line was energized each day from 5 a.m. to 4 p.m. for testing. It became apparent that at about 9 each morning, the readings at both test sites would

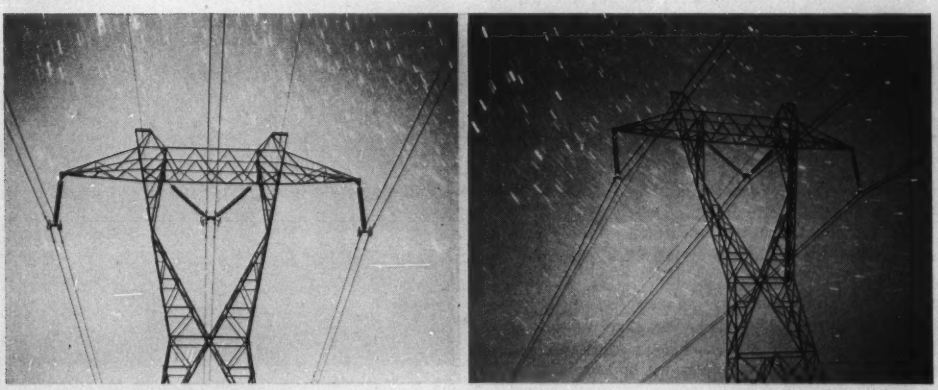


Fig. 4. Night photographs comparing insulator corona at both sites on a clear night at approximately 350 kv—(left) *main test site with control rings;* (right) *main test site without control rings*

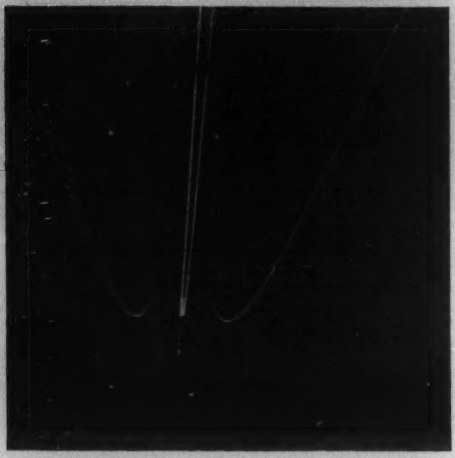


Fig. 5. Night photograph during snow storm. Note that center phase has more corona than outside phases, and spacers less corona than conductor

drop from a fairly high to a normal daily RIL. After observing this for several days, it was decided to leave the line on continuously and thus eliminate the high initial morning readings.

The rather high levels during daily burn-off were believed caused by moisture and dust particles settling on the conductor overnight.

Rain and Snow. An increase from light to heavy rain causes a steady increase in RIL on the line, with the highest level being associated with the heaviest rain. Increases up to 10 times the prerain RIL were recorded. After rain or snow, the RIL of the transmission line soon returns to normal fair-weather levels.

The RIL was rarely noted to rise before the start of precipitation at the actual measurement location. This and other attenuation tests indicate that measurements made at one location are not affected by precipitation on the line a few miles away.

Snow and rain apparently have the same effect on the conductor which is the primary source of RI in foul weather. Photographs taken during a snow storm show the center phase in corona first, then the outside phases. This agrees with calculations showing that the center phase has the highest gradient and should become critical before the outside phases; see Fig. 5.

Akron, Ohio, weather data for an 8-year period showed that precipitation of 0.1 inch per hour or more could be expected less than 1.5 per cent of the time. Thus foul weather sufficient to cause radio disturbances probably occurs less than 1.5 per cent of the time in the Ohio Edison area and would not be considered a determining factor in line design.

Dew and Fog. It was observed that enough moisture must be present to cause water droplets to form on the conductor before the RI of the line is materially affected.

One night, during a heavy fog with an occasional light mist, a very low 60-cycle hum was heard. Photographs taken at that time showed the preformed spacer rods to have a faint glow, Fig. 6, while the conductors were practically corona-free. In this type of weather, the preformed spacers had a lower corona threshold voltage than the conductor; however, in rain and snow the conductor goes into corona before the spacers.

Line Tests. On two occasions six meters were stationed along the line so that tests could be made at exactly the same time. The curve in Fig. 7 shows the results. Between the plant and the open end the readings show a gradual increase toward the open end. Other lateral tests taken at various times along the line substantiate the increase toward the open end. A possible cause of this increase is the 2 per cent voltage rise from the plant to the open end; plus other unknown causes.

The temporary connections at the dead-end towers, at the plant end and at the open end of the line, resulted in high readings at these locations.

Attenuation Tests. It was found that the dead-end tower at the open end was the source of a very high RIL. With this tower as a source, one meter was located near the source which recorded the RIL of the line. Another meter was used to measure the RIL at various distances from the dead-end tower to check the attenuation of the line.

Fig. 8 giving the attenuation curve, shows that the RIL has attenuated to a normal level within 4 to 5 miles. This indicates that the measurements at any location are not materially affected by precipitation on the line approximately 5 miles away.

Fig. 6. Night photograph during heavy fog shows very little conductor corona; spacers' corona is caused by water droplets forming on the rods of the spacer

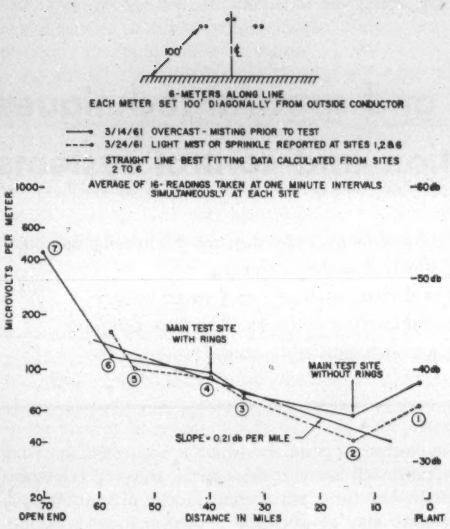


Fig. 7. Line test with 6 meters

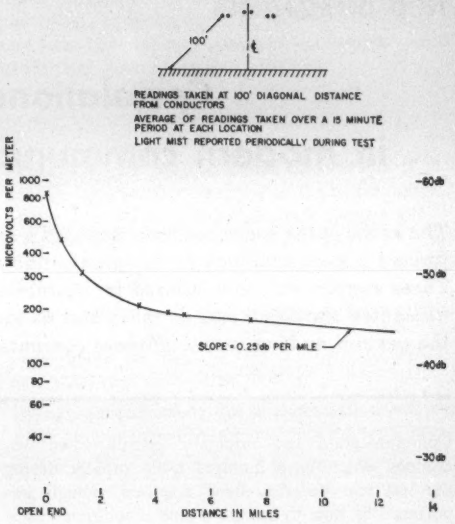


Fig. 8. Attenuation curve

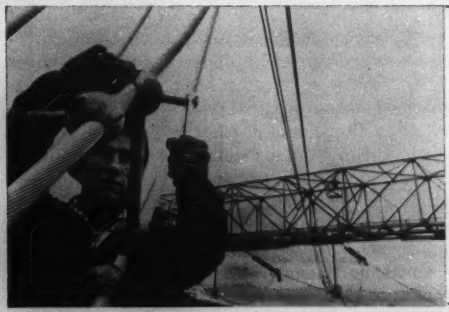
Comparison of Laboratory and Field Tests. Photographs of corona on conductor suspension assemblies, taken in the field and compared with laboratory results, indicate little change in moving from the laboratory to the field. The corona start voltage in the laboratory and in the field are approximately the same for fair weather conditions.

The conductors were free of visible corona in fair weather, except for an occasional isolated source, throughout the nominal 345-kv range, which generally agrees with laboratory results.

CONCLUSIONS

1. Corona rings have little or no effect on the RIL of the line and will not be used on future 345-kv conductor hardware assemblies for lines of this design.
2. Corona start voltages for conductor hardware assemblies tested in the laboratory were found to be in close agreement with the field tests.
3. Foul weather occurs less than 1.5 per cent of the time in the Ohio Edison Company territory and should not be a principal factor in line design.
4. Night tests and photographs proved very valuable in the investigation of the line.
5. The conductor is the major cause of radio influence in foul weather and probably is the primary cause in fair weather.
6. Readings made at one site are not materially affected by precipitation on the line approximately 5 miles away.

HELPFUL DUMBBELL



The dumbbell-like device in this man's hands is helping the electrical utility industry ready itself for a giant-step to a future power transmission level of up to 750,000 volts—over 10 times the power-carrying ability of today's typical 220,000-volt line.

Called "bundled conductor spacers," the devices were developed by Alcoa Research Laboratories for installation on the "Project EHV" prototype transmission system. Located near Pittsfield, Mass., the project—under sponsorship of General Electric Company—is seeking information that will assist utilities to transmit at higher voltages in the future to fill the nation's ever-increasing power appetite.

N. D. DIAMANTIDES

Correlational and spectral techniques in modern communication and control systems

The needs of the space age have imposed a severe burden on information-gathering media, forcing a new approach to communication and control systems design. These systems are now tailored for system-to-signal compatibility and must reject unwanted statistical signals that enter as unavoidable disturbances. For this purpose the general and/or special purpose computer is an indispensable tool

Communication and automatic controls, two disciplines which have matured quite rapidly during the last two decades, have acquired enough importance by now to initiate a true revolution in applied science and the associated industrial activities. The commencement of the space age is a most dramatic proof of their importance. Neither satellite orbiting nor space probing is imaginable without controls of high accuracies for the keeping of vehicles on predesigned trajectories, or without communication links of comparable efficiencies for endowing the vehicles with a scientific or other purpose.

The most striking common feature between communication and control is the fact that both operate on, or through, statistical signals which carry information and commands between a mechanistic system and its environment in general. Both also have to overcome other statistical signals which enter the system as undesirable but unavoidable disturbances. It therefore becomes imperative, although not always easy, that communication and control systems be tailored to the nature and the quantitative aspects of the statistical signals which they are expected to encounter.

This new approach to system design is in marked contrast with conventional synthesis procedures which are based on the assumption that the specifications on performance can be accurately interpreted in terms of the characteristics of the sinusoidal or step-function response, an assumption obviously resulting in a greater or lesser design artificiality. In proceeding with a system tailored toward achieving system-to-signal compatibility, the analyst discovers very early that general and/or special purpose computers are indispensable.

One type of a statistical signal that we will use to illustrate a point and which is acquiring increasing significance lately is the optical array of brightness cells that form any 2-dimensional picture. Such a picture may be obtained through a number of sensors, the most important ones being ordinary visual photography, radar and infrared. Contemporary warfare technology, in particular, is pressing hard on pictures and displays representing the output of these sensors, in an effort to extract the last bit of information possible from them.

INFORMATION NEEDS OUTPACE LEVEL OF TECHNOLOGY

Under the impact of the new, faster, and more potent weapons of both strategic and tactical warfare, information gathering from the air is evolving toward more efficient devices and techniques. The very same pressure, however, is multiplying the informational needs at a faster pace than the equipment evolution affords. The reason is that in order to lessen the losses which modern offensive weapons are capable of inflicting, dispersal and high mobility become a major preoccupation of armed conflict. This, of course, greatly enlarges the extent of the theater of operations as well as the number of important targets of interest.

The burden imposed upon the information gathering media becomes obvious: large amounts of it have to be acquired, processed, and classified, covering an increasing variety of targets observed under all kinds of cover, weather, and illumination. This obviates both the potentialities and the problems associated with pictorial displays in their role as input signals to either the human perceptual system or to an electro-optical mechanism. Such nonhuman mechanisms are becoming subjects of increasing technological effort as hardware solutions of many serious problems of the space and missile age are sought.

Automatic systems are relied on more and more in implementing star tracking, surveying, and terrain

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and target recognition for terrestrial navigation, reconnaissance, battlefield surveillance, lunar and planetary mapping, and exploration.

As already mentioned, these systems will have to be designed on the basis of quantitative characteristics of their inputs. Hence, the pictures themselves will have to be known in precise statistical terms.

Under the present state of the art, determination of the response of a system to a statistical input, like the pictorial display, rests heavily on the concept of correlation, which denotes the degree of dependence of any elemental picture area on the rest of the picture.

The spatial picture correlator[1,2] is one means of implementing the concept, making possible the measurement of similarity between two displays. One technique of such measurement employs two pictures, A and B, Fig. 1, both taken positive for the purpose of the present discussion, juxtaposed, and illuminated by a uniform collimated beam from a constant-intensity light source. It is assumed that the displays are transparent, their elements being expressed as transparency gradations. The light transmitted through the pair is directed by a collector lens onto a phototube followed by an amplifier, the arrangement giving rise to a voltage proportional to the total emerging flux.

Let the transparency function of the two pictures be $T_A(x,y)$, $T_B(x,y)$, where $0 \leqq T \leqq 1$. If the incident light beam has an intensity of I units per unit area then an infinitesimal picture area *(dx dy)* will result in a light flux output of

$$I\ T_A(x,y)\ T_B(x,y)\ dx\ dy$$

where it is assumed that the pictures are held in perfect register. If, however, the two pictures are displaced in parallel with respect to each other without azimuth disorientation, the flux emerging from the same element will be

$$I\ T_A(x,y)\ T_B(x+a,\ y+b)\ dx\ dy$$

where a and b are the displacements in the x and y axes respectively.

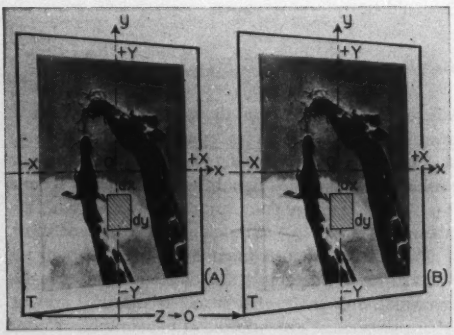

Fig. 1. Picture correlation by superposition

For simplicity, the over-all gain of the phototube and associated multiplier is set equal to $1/I$ volts per unit flux. Then the final output of the correlator due to the total picture area is

$$R'_{AB}(a,b) = \int_{-X}^{X} \int_{-Y}^{Y} T_A(x,y)\ T_B(x+a,\ y+b)\ dx\ dy$$

where $\pm X$, $\pm Y$ are the corner co-ordinates of the rectangular area delineated within the picture frame. The average value of this expression appears as

$$R_{AB} = \lim_{X,Y \to \infty} \left[\frac{1}{4XY} R'_{AB} \right]$$

which is by definition the cross correlation function.

PROPERTIES OF THE AUTOCORRELATION FUNCTION

The expression becomes the autocorrelation function if the two transparencies are copies of the same negative; i.e., $T_A = T_B = T$:

$$R(a,b) = \lim_{X,Y \to \infty} \left[\frac{1}{4XY} \int_{-X}^{X} \int_{-Y}^{Y} T(x,y)\ T(x+a,\ y+b)\ dx\ dy \right] \quad (1)$$

The autocorrelation function, or "autocorrelogram," of a picture appears to be one of a class of functions of considerable value in the analysis of any control or communication system in which the picture contents are significant as input signal sources. Since these signals are of random nature, their correlogram is a very fruitful method of comparison between them and the resulting system outputs. The function $R(a,b)$ gives a measure of the interrelation between the various picture elements placed at a distance (a,b) apart on the x-y plane. It is to be expected that as the offset (a,b) increases, the interrelationship or memory must weaken and, in the end, when the offset is very large, $T(x,y)$ and $T(x+a,\ x+b)$ will be completely decorrelated. Thus, a dark element from the one copy is as likely to be juxtaposed to a bright one from the other copy as it is to coincide with a dark one. Therefore, the average of the product $T(x,y)\ T(x+a,\ y+b)$ does not change with a,b any further and the surface $R(a,b)$ levels off. The opposite is true when the offset is zero, $a = b = 0$, resulting in a marked peak at the origin.

Two more properties of the autocorrelation function should be emphasized: First, it is an even function in a,b:

$$R(a,b) = R(-a,-b)$$

This is true because $R(a,b)$ is measured by shifting the function $T(x,y)$ by a,b ahead and averaging the product of the original and shifted functions; $R(-a,-b)$ is measured by shifting the function backward by $-a,-b$ and averaging in a similar manner. Since the range of integration of the product in

either case is from $-\infty$ to $+\infty$, the origin is immaterial and the averaged product is independent of the direction of the shift.

Second, if the original function were to be written as

$$T(x,y) = \overline{T(x,y)} + T_v(x,y)$$

where $T_v(x,y)$ denotes the variation of $T(x,y)$ about its mean value $\overline{T(x,y)}$, then its autocorrelogram may be expressed as

$$R(a,b) = [\overline{T(x,y)}]^2 + R_v(a,b)$$

since by definition $\overline{T_v(x,y)} = 0$.

Obviously $[\overline{T(x,y)}]^2$ is the "d-c" component of $R(a,b)$ and could be ignored without any loss of essential information, leaving

$$R_v(a,b) = \lim_{X,Y \to \infty} \left[\frac{1}{4XY} \int_{-X}^{X} \int_{-Y}^{Y} T_v(x,y)\ T(x+a,\ y+b)\ dx\ dy \right] \quad (2)$$

Fig. 2 shows the autocorrelation surface of the picture accompanying it as a photographic density field proportional to $R(a,b)$ at each point (a,b).[3]

It is obvious from this discussion that the picture correlator is an efficient special computer whose purpose is the performance of the mathematical operation in two dimensions given by equation 1. There is more to be gained from the correlogram, however, if advantage is taken of the convenience and speed available in modern computers.

The most valuable attribute of the correlogram is the fact that it is equivalent to a rigorously derived frequency function which lends itself to application of control theory in the frequency domain to signals which are fundamentally nondeterministic. As it is, the correlation function describes signals in the time domain, essentially, and not in the frequency domain. To simplify the derivation, let us reduce the problem

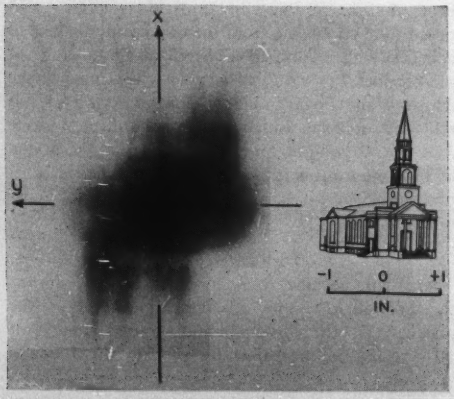

Fig. 2. A picture and its correlogram

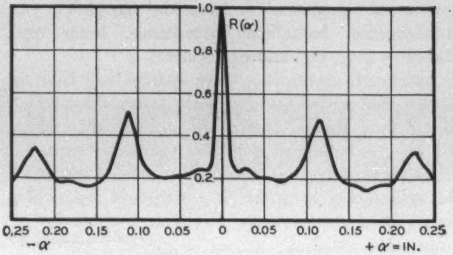

Fig. 3. Autocorrelation curve of the picture in Fig. 2

to its 1-dimensional case by simply keeping the offset equal to zero along the y-axis; i.e., $b = 0$. This makes equation 2

$$R_v(a) = \lim_{X,Y \to \infty} \left[\frac{1}{4XY} \int_{-X}^{X} \int_{-Y}^{Y} T_v(x,y) T_v(x+a,y)\ dx\ dy \right] \quad (3)$$

which corresponds to the plane curve of the intersection of the correlogram surface $R_v(a,b)$ and the plane $y = b = 0$ through the peak of the surface. For the particular surface of Fig. 2, the corresponding curve is shown in Fig. 3 as the locus $R(a)$ normalized to the peak value $R(0)$.

It can be shown without much difficulty that the function describing the signal $T(x,y)$ in the frequency domain and carrying exactly the information contained in the autocorrelogram is the Fourier transform of equation 3

$$R_v(j\omega) = \int_{-\infty}^{\infty} R_v(a) \exp(-j\omega a)\ da \quad (4)$$

It should be emphasized that the transition from equation 3 to equation 4 represents a step of considerable theoretical as well as utilitarian value. The function $T_v(x,y)$ is certainly of a statistical nature and its deterministic appearance in the foregoing discussion was only a convenience in order to illustrate the physical meaning of correlation. A more appropriate expression for the definition in equation 3 would be

$$R_v(a) = \int_0^1 \int_0^1 T_{v1}\, T_{v2} P(T_{v1}, T_{v2}, a)\ dT_{v1}\ dT_{v2}$$

where T_{v1} and T_{v2} are the signal values at two points a units of distance apart, and $P(T_{v1},T_{v2},a)$ the second probability density function; i.e., the probability that the signal lies between T_{v1} and $T_{v1}+dT$ at a given point and at the same time between T_{v2} and $T_{v2}+dT$ at a point a units distant.

Thus, the autocorrelation analysis offers an advantage in the manipulation of statistical processes for which only the probability distribution is known. These processes are not directly accessible to the theoretical Fourier analysis, whereas, under certain

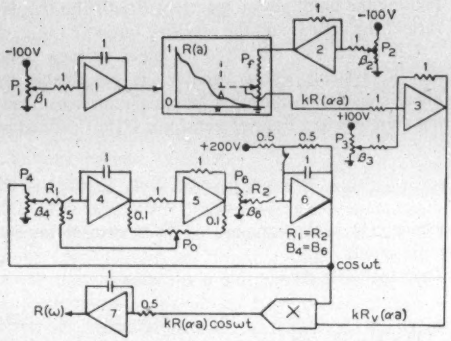

Fig. 4. Computer diagram for the derivation of the frequency spectrum

conditions (ergodic hypothesis), the autocorrelation function can be directly computed from the probability distribution. From this function and through a Fourier transformation the frequency spectrum of the statistical signal is obtained.

The same analysis makes clear the meaning of $R(j\omega)$. The power carried by the signal in the frequency band from ω_1 to ω_2 is simply $1/2\pi$ times the integral of $R(j\omega)$ between the same limits of ω; i.e., if the signal were the voltage across a 1-ohm resistor, this integral will yield the power dissipated in the resistor by all signal components having frequencies lying within the range ω_1 to ω_2.

Consequently, the frequency function $R(j\omega)$ renders itself very conveniently to the design of filters and compensators which will optimize the control or communication system concerned with $T_v(x,y)$ from the point of view of speed, stability, linearity, and noise.

CONTRIBUTION OF GENERAL-PURPOSE COMPUTER

Because, as already mentioned, the autocorrelogram of a noiseless signal is an even function of a, i.e., $R_v(a) = R_v(-a)$, equation 4 reduces to

$$R_v(\omega) = 2\int_0^\infty R_v(a)\cos\omega a\, da \qquad (5)$$

This is a decisive step at which a general purpose computer may contribute significantly as the following case will indicate.[4]

To implement the computation of $R_v(\omega)$, the experimental function $R(a)$ of Fig. 3 was inserted in a curve follower through which the amplitude $R(a)$ was depicted by the follower output voltage, while the independent variable a (length) was translated into time. The integrating amplifier 1, Fig. 4, in combination with the biased potentiometer P_1 caused the curve-follower sensing element to move uniformly along the horizontal axis to a distance

$$x = 100\beta_1 t$$

where with x in inches and t in seconds, 1 inch on the follower represents 0.35/15 inch on the original picture.

The gain-setting amplifier 2 and potentiometer P_2 served to bias the curve follower potentiometer P_f so that the autocorrelogram peak $R(0)$ was represented by 100 β_2 volts. Through the adder amplifier 3 with its associated potentiometer P_3 the voltage replica $kR_v(\alpha\, a)$ of the correlation function is obtained, with

$$\alpha = \frac{0.35}{15 \times 100\beta_1} = \frac{7}{3\beta_1}\,10^{-4} \qquad (6)$$

$$k = 100\beta_2$$

Concurrently with the generation of $kR_v(\alpha\, a)$ the weighing function cosωt present in equation 4 was realized by means of an oscillator composed of the three amplifiers 4, 5, and 6.

Both these functions, of course, are fed into an electronic multiplier, the output of which is averaged by means of the integrator 7.

The purpose of the potentiometer P_0 is to insure the proper amount of positive or negative feedback for a constant amplitude oscillation at the oscillator output, which is given as

$$e = 100\cos\omega t \text{ volts}$$
$$\omega = \sqrt{\frac{\beta_4\beta_6}{R_1R_2}} \text{ rad/sec} \qquad (7)$$

Taking into account the parameters involved, we find that the computer output will be

$$R(\omega) = \frac{14\beta_2}{3\beta_1}\,10^{-2}\int_0^\infty R_v(\alpha\, a)\cos\omega\alpha a\, da \qquad (8)$$

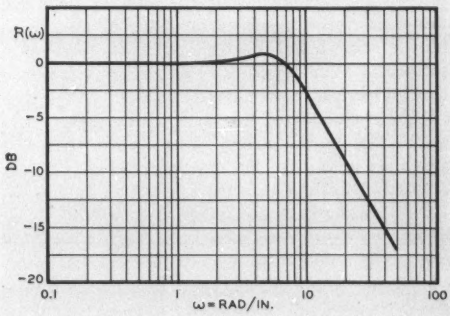

Fig. 5. The frequency spectrum corresponding to the curve of Fig. 3

where all the parameters involved have been accounted for.

After the scale factors have been decided upon and the circuitry has been programmed on the analog computer, the computational procedure consists of setting the potentiometers P_6 and P_4 to correspond

to a selected value of ω in accordance with equation 7, and closing of the quadruple switch S which initiates the whole operation. The computation is allowed to proceed up to the time $R_\psi(a)$ has reached a value less than 1.0 per cent of its peak value $R_\psi(0)$ at which point the output of the integrator 7 is read. The switch is opened, all integrators discharged, a new setting of ω is effected, and the operation is started over again.

Thus, $R_\psi(\omega)$ is constructed point by point, as shown in Fig. 5, for the autocorrelogram $R(a)$ in Fig. 3.

This particular example was selected only to give a realistic illustration of the method which is one of several available. The example has some significance, however, when attention is focused on the perspective drawing itself, Fig. 2, in an attempt to study it quantitatively and search for possible correlates between $R_\psi(\omega)$ and the architectural style involved or the picture's perception by the human observer.

Suppose for a moment that the picture of interest was that of the other side of the moon and it was intended to be recorded somewhere in the brain of a

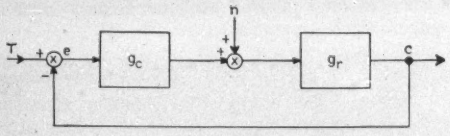

Fig. 6. A simple control loop

rocket by means of a given technique such as television, in order to be transmitted to a receiving station on the earth at some more opportune point of the rocket's journey. Or suppose that the picture is that of a given area of enemy territory snapped and stored inside an American spying satellite that was tossed into polar orbit, and that the satellite was to be interrogated by a communication link every time it passed over properly equipped ground stations in the continental United States. Knowledge of the power spectrum of the original picture of the lunar or terrestrial area may then make the difference between a successful mission and a scientific or military dud.

Only on the basis of this spectrum can one hope to design a satisfactory recorder and communication link, avoid undue distortions of the pictorial signal, combat noise, and achieve the intelligent system-to-signal compatibility mentioned at the beginning of this article. Let us see why.

As in all problems in dynamic analysis the basic tenet on which all hope rests is the uncovering of the mathematical characterization of cause and effect relationships for the general system on hand as well as its elements.

Probably the most basic mathematical expression one can derive in regards to the application of statistical design principles to specific problems is the one relating the input power spectrum $R(j\omega)$ with the nature of the system and the resulting output $P(j\omega)$.

Let us restrict ourselves to linear systems only, that is, systems whose behavior is describable by linear constant coefficient differential equations, leading therefore to a Fourier transform $G(j\omega)$ defined as

$$G(j\omega) = \int_{-\infty}^{\infty} g(t)e^{-j\omega t}\,dt \tag{9}$$

where $g(t)$ is the response of the system to an impulse input.

Then the basic relationship in question is

$$P(j\omega) = |\,G(j\omega)\,|^2\,R(j\omega) \tag{10}$$

The meaning of this expression may be explained as follows. If one knows the power spectrum; i.e., the frequency components, $R(j\omega)$, of the signal he is concerned with, as well as the response, $G(j\omega)$, of the system available for the transmission or processing of the signal, he is in position to compute what the end result will be, i.e., how distorted the signal will appear at the output of the system. If this result is unsatisfactory, equation 10 provides direction as to how the system should be modified or what compensators should be used in order to make the outcome acceptable. This is the case of a straight open-loop performance such as the already mentioned communication link.

The procedure becomes much more interesting when the picture of the target area on the moon or in enemy territory is supposed to be the command guiding the rocket itself, with its picture-taking equipment, toward that area. The situation can be visualized by means of the block diagram of Fig. 6 where the ultimate goal is to keep the quantity c as close to $T(x,y)$ as possible; i.e., to keep the error e at the minimum level possible. This has to be achieved in spite of the presence of extraneous disturbances $n(t)$, which might be due to atmospheric turbulence in the vicinity of the earth, for instance. The diagram depicts the control situation in one dimension only, such as yaw, or pitch of the vehicle.

We can find the expression for $e(t)$ from the diagram in a straightforward manner

$$E(j\omega) = \frac{T(j\omega) - G_c(j\omega)\,N(j\omega)}{1 + G_c(j\omega)G_r(j\omega)} \tag{11}$$

where all symbols involved signify the Fourier transform of the corresponding signal or system function. G_r and G_c are the response functions of the rocket and its control system respectively. The power spectrum method gives very readily the relationship and interaction between input, T, error e, and the response functions of the two major components involved in spectral form:

$$R_e(j\omega) = \left|\frac{1}{1 + G_c(j\omega)G_r(j\omega)}\right|^2 [R_T(j\omega) + |G_c(j\omega)|^2\,N(j\omega)] \tag{12}$$

Here again the statistical approach gives a definite measure of the average amplitude of the various error-frequency components in terms of the statistics of the input signal (picture), of the expected disturbances, and of the dynamics of the rocket system. Intelligent system design, filtering, and compensating therefore become possible.

The actual cases of space and missile hardware are, of course, much more complex than the skeletal one of Fig. 5. Multiple control and communication loops are involved, the unwanted disturbances arise from many sources, and the causes of initial errors and tolerances are numerous. Nevertheless, if the systems are basically linear or can be treated by means of quasi-linear techniques, their design and function becomes amenable to quantitative synthesis through the statistical approach sketched here and with the help of computers.

As the race around and away from the terrestrial globe becomes more and more competitive, the contestant who gets there first is the one who possesses not only the better and more powerful equipment, but also the more subtle theoretical tools to deal with the complicated statistics of systems and signals. Although present methods of analysis and synthesis are sophisticated, the need for such new tools is already with us, as in the case of nonlinear systems, many of which can outdo their linear counterparts. A complete nonlinear mathematical analysis usable by engineers is yet to be developed.

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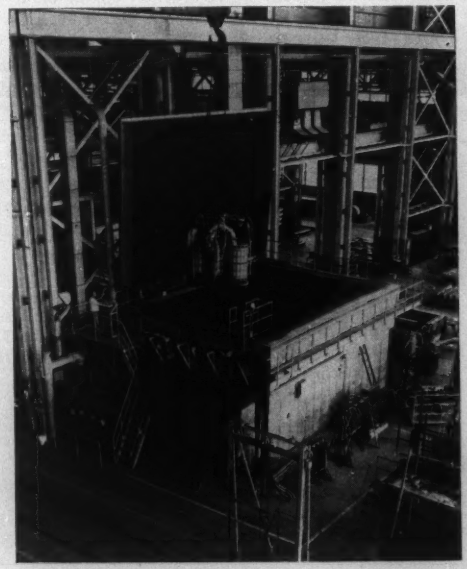
VACUUM-DRYING SYSTEM FOR ELECTRICAL INSULATION

Electrical insulation for Allis-Chalmers power transformers, produced at their Terre Haute (Ind.) plant, is conditioned by one of the finest vacuum-drying systems in the world. The drying chamber equipment, designed and supplied by the F. J. Stokes Corporation, Philadelphia, combines the effects of vacuum and automatically controlled heat under strict regulation to insure a high-quality electrical insulation.

Dielectric strength of an electric system depends on the resistance of all its insulating components to electrical failure. Since failure can result from both physical and electrical causes, extreme care must be taken to prevent impairment of the insulation during all the processes it is subjected to. Drying is one of the most critical because insulation normally absorbs large quantities of moisture. This must be removed because it forms a conducting film throughout the insulating material and thus reduces its electrical resistance.

The drying chamber measures 18 feet by 27 feet and is 26½ feet high. It is designed for full vacuum application and is structurally reinforced with 21-inch *W.F.* I-beams on 14½-inch centers. As many as five power transformers can be processed in the chamber at one time. Easy loading and unloading of the chamber is made possible by its full-opening top cover, which is hinged along the 27-foot side and can be swung up to a vertical position for these operations.

Previously, a typical insulation load required from 1 to 3 weeks to dry. Now, the drying cycle is completed in well under 24 hours. In addition to the lower manufacturing costs which are thus obtained, the rapid drying cycle insures that no insulation aging takes place, although a higher degree of dryness is achieved than is possible with conventional equipment. The equipment, operating at pressures as low as 4 mm Hg, dries out the transformers in a shorter time, and at a lower temperature, than would be possible at atmospheric pressure.



A. ELEK and J. W. SIMPSON

Safe clearances and protection against shocks during live-line work

An equation, based on the highest switching surges and including safety factors, is developed for the limit of approach to live parts of transmission lines. The effect of temporary protective gaps is shown, and the mechanism of shocks experienced by linemen during loose contact with a tower is discussed. Such shocks, although harmless, are annoying and can be avoided by the use of conducting shoes

Live-line maintenance is performed by many utilities with a high degree of safety at all voltage levels now used. It will be expedient to extend this practice to lines operating at voltages of 460 kv and over, but in so doing it seems advisable to analyze the possible hazards which may be encountered and to see how the present degree of safety can be maintained.

Essentially, two factors have to be investigated: the specification of the required minimum distance between live parts of the line and the lineman, and the physiological effect of the electrostatic field at the tower.

Design clearances increase with higher line voltages with a corresponding increase in the length and weight of live-line tools. The specification of clearances greater than necessary may result in tool lengths which would make live-line work difficult, if not impossible.

Furthermore, on extra-high-voltage (ehv) lines, the shocks to which the linemen are exposed become excessive. Although these shocks are not injurious, they can cause accidents of a secondary nature: loss of balance, dropping of tools, etc.

In an analysis of the various factors pertinent to live-line work on extra-high-voltage lines, a review of the present practice at lower transmission voltages is inevitable. The results of the following analysis will therefore be applicable to all voltage levels.

LIMITS OF APPROACH DURING LIVE-LINE WORK

The minimum distance permissible between a lineman and any live part of the line is determined by the highest potential difference which can occur across that distance. The clearance must be large enough to prevent flashover under any circumstances, even if the lineman reaches inadvertently beyond the specified limit. It is suggested therefore that the following equation be used to determine the smallest permissible clearance between the lineman and any live part of the line

$$D = A + b \times F \qquad (1)$$

D = limit of approach defined as the smallest permissible distance from any part of the lineman's body or from

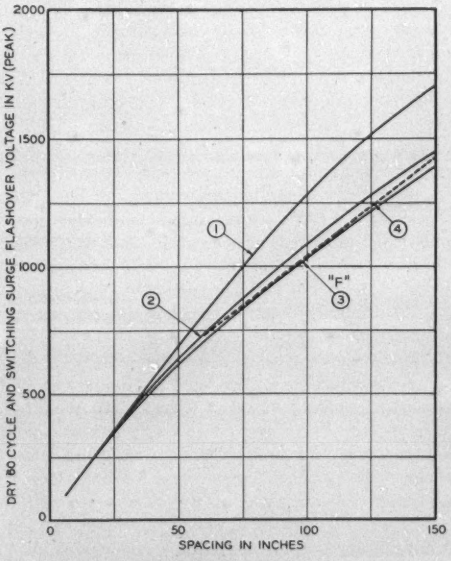


Fig. 1. Dry 60-cycle and switching surge flashover voltage of air gaps. (1) Rod-rod, 60-cycle flashover;[1] (2) Rod-plane, 60-cycle and switching surge flashover;[2] (3) Grading ring—tower 60-cycle and switching surge flashover;[3] (4) Grading ring—tower, switching surge flashover[4]

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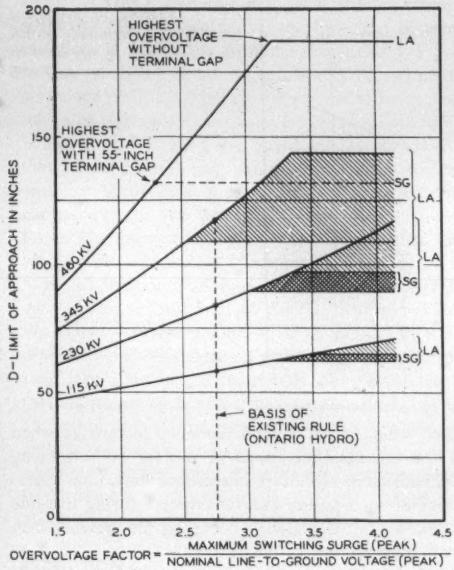

Fig. 2. Relation between limit of approach and overvoltage factor. $D = 36 + 1.25$ F inches (F from Fig. 1); SG, spark gap; LA, lightning arrester

any conducting object he may be handling to any live part of the line

F = spacing of a phase-to-tower gap, the peak switching surge flashover voltage of which is equal to the highest transient voltage which can occur between the conductor and ground

b = safety factor which provides assurance that switching surges will cause no flashover, irrespective of the wave-shape, electrode configuration, or atmospheric conditions

A = safety factor which provides for a momentary reduction of clearance caused by a lineman who, breaking the rules, inadvertently reaches into the prohibited area coincidently with an overvoltage on the line

The highest switching surge has either to be calculated or determined by model studies. The value of F can then be found from curve 3 of Fig. 1. Curve 3 represents the lowest flashover voltage that has been reported in the literature for any electrode configuration.[3,4] The flashover voltage indicated by curve 3 was measured across a horizontal gap on a tower between a grading ring and the tower leg. It is equal to the 60-cycle flashover voltage of the gap.

It is necessary to multiply F by a safety factor b which provides assurance that no flashover will occur across the clearance under any circumstances. Previous studies indicate that the reduction of the 60-cycle flashover voltage due to atmospheric conditions and random variations does not exceed 25 per cent of its average value. It is therefore suggested that $b = 1.25$ be used.

For two reasons, this approach may seem conservative. First, the highest overvoltages are often high-frequency transients and for such exposures the flashover voltage of an air gap may be higher than for 60-cycle or low-frequency transients. It is shown by Tikhodeev and Tushnov[2] and by Wanger and Huber,[5] however, that the flashover voltage of an air gap in the case of switching surges associated with long lines does not differ appreciably from its 60-cycle flashover voltage. Hence, if the calculations are based on the 60-cycle flashover voltage, the safety margin will not be unduly large for long lines. The second reason that the approach may seem conservative is the assumption of electrodes with the lowest possible flashover voltage. It can be seen from Fig. 1, however, that the configuration "phase to tower" (or "grading ring to tower") follows very closely the rod-plane type of electrode configuration which is representative of most practical cases. Therefore the safety margin could not be decreased for this reason.

The additive safety factor A provides safety in the event of an inadvertent approach beyond the specified limit. Since it is unlikely that a lineman would misjudge the safe distance by more than 3 feet, and experience indicates that this value is realistic, it is suggested that, under normal conditions, for horizontal clearances in air, $A = 36$ inches be used. Under exceptional circumstances a reduction of this factor can be allowed, provided other precautions are observed simultaneously. If, for example, barriers are used or where the approach to a live part is only of short duration (for instance during climbing), the value of A may be reduced.

For vertical clearances where an inadvertent approach is less likely and for clearances along live-line tools during certain controlled live-line work, the value of A may also be reduced. The flashover

Table I • SPARKOVER VOLTAGE OF PROTECTIVE DEVICES, SWITCHING-SURGE OVERVOLTAGE FACTORS, AND CALCULATED LIMITS OF APPROACH DURING LIVE-LINE WORK ON 115 – 460-KV SYSTEMS

System Voltage (kv)	Protective Device at Two Ends of Line	Highest Switching-Surge Sparkover Voltage of Protective Device,* kv_{peak}	Overvoltage Factors Corresponding to Column 3	Highest Overvoltage Factor Actually Considered	Limit of Approach Corresponding to Column 5, feet
1	2	3	4	5	6
115	Lightning arresters, 18- to 20-inch gaps	300 – 495 300 – 330	3.20 – 5.30 3.20 – 3.50	2.75	5
230	Lightning arresters, 36- to 40-inch gaps	560 – 990 570 – 630	3.00 – 5.30 3.05 – 3.35	2.75	7
345	Lightning arresters,	725† – 945	2.55 – 3.35	2.75	10
460‡	Lightning arresters, 55-inch gaps (only during live-line work)	1,200† 850	3.20 2.30	3.20 2.30	15½ 11

* Figures in this column are believed to agree with the practice of most utilities in the United States and in Canada

† Since these voltages are equal to or lower than the highest switching surges considered (compare columns 4 and 5), sparkover of lightning arresters during some switching operations is likely to occur

‡ Data based on preliminary specifications for the ehv system presently being designed for northern Ontario

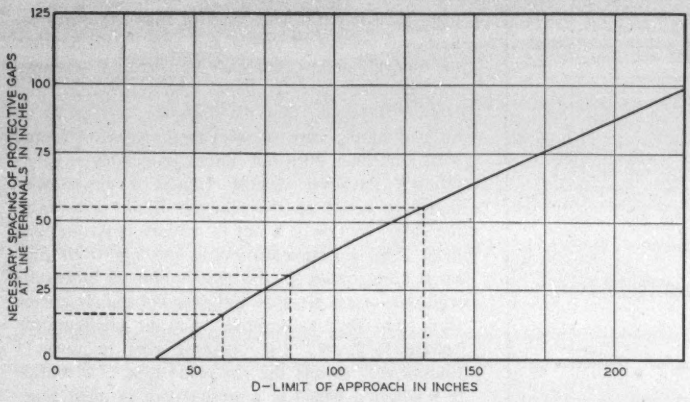

Fig. 3. Spacing of protective gaps at line terminals which allow reduction of the limit of approach

voltage of live-line tools was found to be identical to that of an air gap of equal spacing.

In Fig. 2 the limit of approach is plotted as a function of the highest internal overvoltage. This overvoltage is expressed as a multiple of the nominal peak line-to-ground voltage which is called "overvoltage factor." To illustrate the procedure of plotting Fig. 2, assume, for instance, a 230-kv system and an overvoltage factor of 2.75. Hence, the peak of the highest overvoltage will be

$$E_m = 2.75 \frac{230}{\sqrt{3}} \sqrt{2} = 516 \text{ kv}$$

From curve 3 of Fig. 1 it is found that the largest spacing of a gap with a peak switching surge flashover voltage of 516 kv is 38.5 inches. Substituting $F = 38.5$ into equation 1, the limit of approach will be

$$D = 36 + 1.25 \times 38.5 = 84 \text{ inches}$$

The curves of Fig. 2 have been drawn according to this procedure for 115-, 230-, 345- and 460-kv systems. The numerical values which served as a basis for the construction of Fig. 2 are summarized in Table I. The limits of approach specified by the safety rules of the utility with which the authors are associated are 5 feet at 115 kv and 7 feet at 230 kv.[6] The distances are based on an overvoltage factor of 2.75 (in terms of nominal system voltage). This factor is presently considered adequate, since, with the exception of one case, there is no record or indication that higher overvoltages ever occurred on the transmission lines of this utility. For 460 kv, however, overvoltage factors exceeding 2.75 must be anticipated because of the associated high 60-cycle overvoltages.

At lower voltages the probability of overvoltage factors exceeding 2.75 is small, but by no means negligible, as indicated by the one case mentioned, in which the factor was at least 2.9. This is especially true where circuit breakers of older design are used which might show a tendency to restrike when a transmission line, open at the far end, is being disconnected. Although intentional switching operations of such nature can be avoided during live-line work, a fault can always occur on the system when switching follows automatically.

There is an upper limit beyond which the clearance D need not be increased. This limit is determined by the flashover voltage of the terminal equipment. When the overvoltage on the line attains a certain level, the weakest piece of equipment at the line terminal will flash over. This piece of equipment is usually either a spark gap or a lightning arrester. Thus, even if the overvoltage were not limited otherwise, it would be still impossible for the actual voltage on the line to exceed a certain limit. This is represented by horizontal lines in Fig. 2. On 115- and 230-kv systems, the overvoltage attains this limit very infrequently.

The highest possible overvoltage which can occur on the line in the case of the operation of a protective device at the line terminal was determined in the following way:

Where lightning arresters are installed, the highest switching surge which can appear on the line was assumed to be equal to the maximum sparkover voltage of the arresters. The assumed ranges of sparkover voltage are shown in Table I and are represented in Fig. 2 by the shaded areas. The higher values are valid for arresters of an older type and for those of high rating. The ranges are believed to be conservative and agree with the practice of most utilities in the United States and Canada, with the exception of the 460-kv class for which no practice has yet been established. For this class, the preliminary specifications for the future ehv system in Northern Ontario were taken as reference.

Where protective spark gaps are installed, the peak of the highest switching surge was assumed to be equal to 1.15 times the average peak 60-cycle flashover voltage of a rod-rod gap (see curve 1 in

Fig. 1).[1] This assumption may yield a voltage somewhat too low for fast transients; however, in those instances in which the flashover voltage of the protective gap is increased, the withstand voltage of the clearance on the tower will be increased by at least the same amount.

Fig. 2 and Table I are based on the assumption that 18- to 20-inch gaps are used in 115-kv systems and 36- to 40-inch gaps in 230-kv systems. This corresponds to the practice of the Hydro-Electric Power Commission of Ontario, and it is believed that many other utilities are following the same practice.

In the foregoing analysis it was assumed that the overvoltage at any point of the line will not exceed the highest voltage at one of its terminals. In those cases in which this assumption is not quite valid, the small variation in the magnitude of overvoltage at various points of the line may be considered as included in the safety factor. Of course, when the highest overvoltage is based on the characteristics of protective devices, only those devices are considered which remain connected to the line after completion of the switching operation which produced the surge.

REDUCTION OF LIMIT OF APPROACH BY TERMINAL GAPS

The previous considerations may lead to a simple way of reducing the limit of approach, without decreasing the degree of safety. This is shown by an example.

Assume that the highest switching surge which can occur on a 460-kv line as determined by special studies is equal to 3.2 times normal line-to-ground voltage. Fig. 2 shows that this requires the specification of a minimum limit of approach equal to 15½ feet. Now, assume that 55-inch spark gaps are installed at the line terminals. These gaps would limit the peak of the possible low-frequency overvoltage to 1.15 times their flashover voltage, that is, to 850 kv. This is equal to 2.25 times normal system line-to-ground voltage. Hence, the limit of approach can be reduced to 11 feet. In Fig. 2 the effect of the gap is shown by the horizontal dashed line.

Gaps of such small spacing, if installed permanently, would appreciably increase the outage rate of the line, since they would frequently flash over from atmospheric overvoltages and on some occasions also from internal overvoltages. They should, therefore, be removed when no live-line work is being performed on the line, or at least their spacing should be increased.

Fig. 3, prepared on the basis of the foregoing principles, shows the required spacing of the gaps at the line terminals if the limit of approach shown by the abscissa is desired. It can be seen that practically any reduction is possible by this method. However, it is not recommended to extend the reduction below certain reasonable limits.

The foregoing method is by no means confined to 460-kv lines. Although it will probably find application mainly on such lines, it may serve as a way to increase the safety of lower voltage lines as well. As mentioned before, overvoltages exceeding 2.75 times normal are possible in exceptional cases. On lines where such overvoltages could occur and no gaps are used, the limits of approach shown in Table I are too small.

In such cases, protective gaps could entirely preclude the small probability of the occurrence of an overvoltage higher than 2.75 times normal voltage. Adjustable gaps can also be helpful in some cases where only two alternatives exist: either to use considerably reduced clearances or not to adopt live-line maintenance at all. In such cases gaps with an appropriate spacing may remove the hazard associated with the reduced clearance and even though they increase the probability of outage slightly, their use may still be more advantageous than de-energizing the line for maintenance work.

Fig. 3 can be used for the selection of the proper spacing of the protective gaps at any voltage level. It is apparent that at 115 and 230 kv the practice of using 18-inch and 36-inch gaps is very close to the requirements imposed by the limits of approach equal to 5 and 7 feet respectively.

Atmospheric surges attenuate rapidly along the line, and equations may de derived to prove that live-line work can be performed safely during thunderstorms at certain distances. However, it is felt that further investigation is warranted, and that, to protect linemen against flashover due to atmospheric overvoltages, all live-line work should be abandoned when a thunderstorm anywhere along the line is reported by the control station. This is the present practice of most utilities.

ELECTROSTATIC DISCHARGES DURING LIVE-LINE WORK

The electrostatic discharges experienced by linemen during live-line work do not constitute any hazard, at least not in a direct way. They are annoying, however; they decrease work efficiency and if they occur unexpectedly, they may lead to accidents of a secondary nature.

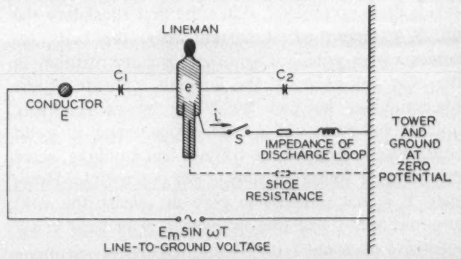

Fig. 4. Equivalent circuit for discharge phenomena on tower

The principle of the phenomenon is explained in Fig. 4. Switch S being open, represents the case in which the lineman is insulated from the tower (standing on a wooden ladder or platform or with rubber-soled shoes on the tower, without touching the steel with his hands). In this case he will assume a potential with respect to ground determined by capacitances C_1 and C_2. If the ground potential is defined as zero and the potential of the line at the peak of the system voltage is E_m, the maximum potential of the lineman will be

$$e_m = \frac{C_1}{C_1 + C_2} E_m \tag{2}$$

Switch S being closed represents the case in which the lineman is in good contact with the tower. In this case his potential will be zero, but a capacitive current will flow from the conductor to his body and from his body to the tower. If the only contact between the lineman's body and the tower is his hand, the current will flow through his arm. The rms value of the current will be

$$i = \frac{E_m}{\sqrt{2}} \omega C_1 \tag{3}$$

where ω is the system angular frequency.

Assume now that a lineman who is at first insulated from ground touches the tower. As soon as the distance becomes sufficiently small, an arc will jump over from his hand to the tower steel and the charge between his body and ground (across capacitance C_2) will be suddenly discharged. Thus, the lineman's potential suddenly drops to zero. The discharge occurs in the form of a damped oscillation which has an extremely small duration (its frequency is in the megacycle range) but is associated with a very high current, since the charge must be removed in a very short time. This high current of short duration causes a shock and unintentional reactions of the hand-muscles, especially if the individual is not prepared for the shock. Apparently, the high current density has an exciting effect on certain nerves. In addition, an annoying effect may be caused by the burning action of the arc.

The phenomenon described usually occurs repeatedly. The high-frequency transient is followed by the 60-cycle capacitive current which flows under steady-state conditions. After the first sparkover the arc is extinguished at current zero; the body assumes a high potential again and the arc restrikes in the next half-cycle. If the lineman is aware of the phenomenon, he can touch the tower relatively quickly by means of a tool. Once being in good contact with the steel, he will not feel anything, since the 60-cycle follow current is not perceptible. However, it is not possible to grab or release the steel to avoid arcing and the occurrence of at least a few repetitive transients.

Should the discharges become intolerable, shoes with conducting soles may be specified for live-line work. The conducting shoes can be represented by a shunt resistance between the lineman and the tower as shown with dashed lines in Fig. 4. Of course, contact to ground is provided only when the lineman stands either on the tower steel or on a conducting ladder or platform.

Tests were made in the laboratory and in the field in order to establish a criterion on the basis of which the severity of various cases could be characterized and compared.

RESULTS OF LABORATORY TESTS

In the laboratory tests, an arrangement was set up, similar to that on the tower and represented by the equivalent circuit of Fig. 4. An arc was drawn between a wrench, held in the hand of a person, and a grounded piece of steel in the vicinity of a high-voltage conductor. The purpose of the tests was to vary the values of C_1, C_2, and E_m and to determine those combinations for which the physiological effect of the discharges was the same. The following was found:

1. When C_1 and E_m were unaltered while C_2 was varied, no change was experienced in the physiological effect of the arc.
2. When C_1 and C_2 were unaltered, it was found that by raising E_m the shock-effect became more pronounced. However, when C_1 was decreased in the same proportion as E_m was increased, the effect remained the same. It was noted that the physiological effect caused by the arc between the body and ground remained constant if the product of E_m and C_1 remained constant.

These observations lead to the conclusion that the quantity which determines the physiological effect of the discharge is the magnitude of the charge flowing through the point of contact during each discharge. The charge flowing through the point of contact between the body and ground when a sudden contact is made is equal to the change in the body's potential multiplied by its capacitance. The former is e_m (since the potential of the body changes from e_m to zero), while the latter is $C_1 + C_2$. Hence, the maximum charge that will flow through the point of contact during each discharge will be as follows:

$$Q_m = (C_1 + C_2)\, e_m$$

or substituting equation 2

$$Q_m = E_m C_1 \tag{4}$$

The following quantitative results were obtained:

1. The minimum charge necessary to produce any perceptible effect in the inside of the hand is on the order of 0.40 to 0.60 microcoulomb. (These values are valid in the case where the discharge occurs through a metallic tool held tightly by the lineman so that no arcing is possible between the tool and

the lineman's hand, but arcing occurs between the tool and the tower.)

2. The smallest charge causing small involuntary muscular reactions when flowing through the inside of the hand is on the order of 0.80 to 1.00 microcoulomb.

3. Other parts of the body show a wide range of susceptibility. For instance, in a case in which the discharge could hardly be felt on the inside of the hand, strong reactions occurred when the contact was made by the fingertips or by the inside of the lower arm. Charges causing violent reactions when flowing through the hands could not be felt at all when flowing through the feet.

4. The figures quoted show variations depending on the individual and on atmospheric and other conditions. When the tests were repeated on 28 persons, it was found that the threshold of perception is higher for manual workers than for persons doing office work. For the former, the median was 0.6 microcoulomb with a standard deviation of 22 per cent. For nonmanual workers, the median was 0.4 microcoulomb, and the deviation, 16 per cent.

The expression for the steady-state current in equation 3 can be seen to contain the product $E_m C_1$ which is the critical charge expressed by equation 4. The magnitude of the steady-state current between the lineman and the tower can therefore be used as a measure for the severity of the discharge which occurs during transient conditions. It must be emphasized, however, that it is the transient which causes the effect and not the steady-state current; the magnitude of the latter is used only as a measure of the former, the two being proportional.

With this in mind, the critical conditions described previously and defined by magnitudes of charges can also be defined as follows:

If the steady-state current through the hand of a lineman during firm contact with the tower exceeds 0.10-0.15 milliamperes (ma), the lineman will begin to feel the effect of discharges as soon as his contact becomes loose. If the steady-state current through his hand exceeds 0.20-0.25 ma, muscular reactions may start at the moment of loosening the tight grip. It is known that under steady-state conditions, currents below 1 ma are not perceptible.[7]

In the following, the steady-state current between the lineman and the tower will be used as a criterion for the severity of the physiological effects experienced during intermittent contacts with the tower.

FIELD TESTS

Tests were made first on a single-circuit 230-kv line and subsequently on Ontario Hydro's 460-kv single-circuit experimental line at Coldwater, Ont. Three linemen who took part in the tests climbed the towers, staying at various positions with respect to the tower and to the conductors. Each contacted a grounded metal part intermittently through an a-c microammeter. Their potential with respect to ground (e_m in Fig. 4 and in equation 2) was measured with an electrostatic voltmeter when the contact was broken, and the steady-state current (i in Fig. 4 and in equation 3) that was flowing to ground was measured with the microammeter when the contact was made.

Table II • CURRENTS AND VOLTAGES MEASURED ON 230-KV TOWER — Line-to-Line Voltage of Conductors: 236-kv rms

Distance of Lineman				Capacitance of Lineman, $\mu\mu f$	
From Conductor, feet	From Tower, feet	i,* ma_{rms}	e_m,† kv_{peak}	to Conductor, C_1	to Tower, C_2
7	5	0.38	14.5	7.2	90
10	2	0.21	6.0	4.0	125

* See Fig. 4 and equation 3
† See Fig. 4 and equation 2

Table III • CURRENTS AND VOLTAGES MEASURED ON 460-KV TOWER — 4-Conductor Bundle, Line-to-Line Voltage of Conductors: 485-kv rms

Distance of Lineman				Capacitance of Lineman, $\mu\mu f$	
From Conductor, feet	From Tower, feet	i,* ma_{rms}	e_m,† kv_{peak}	to Conductor, C_1	to Tower, C_2
10½	6	0.90 – 1.00	38 – 42	8.5 – 9.4	75 – 80
10½	2	0.67 – 0.73	24 – 28	6.3 – 6.9	80 – 110
12	4½	0.75 – 0.80	32	7.1 – 7.6	80 – 85
12	½	0.53 – 0.56	12 – 15	5.0 – 5.3	125 – 170
14½	2	0.42 – 0.49	14 – 17	4.0 – 4.6	90 – 125
16	½	0.31 – 0.36	8 – 10	2.9 – 3.4	120 – 155

* See Fig. 4 and equation 3
† See Fig. 4 and equation 2

It was found that in the field the physiological observations were more dependent on the individuals and on ambient conditions than they were in the laboratory. However, the observed phenomena were compatible with the laboratory results.

The range of the parameters marked in Fig. 4 was in the same order as in the laboratory. Since it is the magnitude of the steady-state current i which indicates the severity of the effects of arcing, the voltage e_m is of secondary importance. But it indicates the maximum length of the arc, and therefore the higher the voltage the longer is the possible duration of the transient condition during the procedure of grabbing or releasing a grounded object.

On the 230-kv line i was found to attain a maximum value of 0.38 ma when the lineman was as close as 7 feet to the conductor. On the 460-kv line values up to 1 ma were measured at a distance of 10½ feet from the conductor. Some representative figures are shown in Tables II and III.

By comparing the figures it may be concluded that in approximately the same position (lineman to tower, 2 feet, lineman to conductor, 10 feet) the steady-state current during firm contact was more than three times higher on the 460-kv tower than on the 230-kv tower, although the line voltage was hardly more than double. This is due to the bundle conductor arrangement with its higher capacitance. The effect of this higher capacitance more than off-

sets the effect of the increased clearance at 460 kv. Thus, at the smallest clearance (7 feet at 230 kv, 11 feet at 460 kv) the steady-state current is 2.5 times higher at 460 kv than at 230 kv, or about 0.90 against 0.38 ma.

Since the steady-state current is a measure of the severity of shocks during intermittent discharges, and it was shown that the threshold of perception is about 0.10-0.15 ma, the discharges will be perceptible both on the 230-kv and on the 460-kv towers, but they will be 2.5 times more severe at 460 kv. The effect of discharges can, of course, be eliminated by the use of conducting shoes.

It can be shown that a resistance of 1 megohm between the linemen's feet and the tower is sufficient to reduce below the threshold of perception the magnitude of charge which is discharged during an intermittent contact. Tests made on commercially available shoes with conducting neoprene soles showed resistances varying from 7,000 to 60,000 ohms for each shoe. The maximum potential between the lineman and the 460-kv tower can thus be reduced to less than 100 volts even in the most severe case.

Layers of paint on the tower and contamination of the soles both increase the contact resistance at low voltage. However, at the voltages occurring on a tower between the lineman and the steel, such insulating coatings will be punctured during the first half-cycle following every change of position. The breakdown voltage of a painted angle-iron with three coatings of paint was found to be less than 750 volts.

CONCLUSIONS

1. The limit of approach during live-line work depends on the highest internal overvoltage that can occur on the line. An equation is presented which fits the present practice on 115- and 230-kv lines, provided that switching surges as high as 2.75 times normal are assumed to apply.
2. The magnitude of the highest overvoltages on future ehv lines cannot be established with general validity. They may be of such magnitude that on account of provisions for live-line work, larger spacings, which may prohibit a more economical design, would be required. In such cases it might still be possible to choose the most economical design and reduce the overvoltages by means of adjustable gaps at the line terminals to a value that fits this design. The spacing of the gaps may be increased except during liveline work. Adjustable gaps can also be used at lower system voltages if increased safety is required or when the limit of approach has to be reduced. A relation between gap setting and the permissible limit of approach is presented.
3. The physiological effects of the electrostatic field on a high-voltage tower consist of harmless but annoying shocks when the contact between the person and the tower is loose. There is no perceptible effect when the contact is firm or when there is no contact. Loose contacts cannot be avoided while the tower is being climbed with insulating footwear or when the tower is touched or released from an insulated ladder or platform.
4. Although, normally, 60-cycle currents below 1 ma are not perceptible, the high-frequency discharge occurring during intermittent contacts will be perceptible when the steady-state 60-cycle current between the lineman and the tower exceeds 0.1 ma. The steady-state 60-cycle current between a lineman and the tower will be about 2.5 times as high on the future 460-kv lines as it is on present 230-kv lines. Hence, the physiological effects will be more pronounced.
5. Conducting shoes eliminate electrostatic shocks completely while climbing the tower and on conducting ladders or platforms while performing live-line work.

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EFFICIENT FLY-ASH ELIMINATOR

One of the world's largest steam-electric generating plants, Ontario Hydro's huge Lakeview Project due to start delivering power this year, will be equipped to remove at least 98 per cent of the fly-ash particles from boiler gases. A contract to provide four electrical precipitators for units 3 and 4 of the 6-unit project has been awarded to Research-Cottrell (Canada) Ltd., (a subsidiary of Research-Cottrell, Inc., leading United States manufacturer of industrial gas cleaning equipment.) The super steam plant will have the largest single furnace boilers installed in Canada—capable of producing 2 million pounds of steam per hour at 2,350 psig at the turbine, with superheat and reheat temperatures of 1,000 F.

PROGRESS IN TECHNOLOGY

Plasma Engine for Satellites: One of many new Space-Age Developments

Research and development continues at a fast pace as scientists and engineers concentrate on one or more projects directly concerned with space vehicles. These projects cover many fields of interest and often contribute much to our general progress in technology. Reviewed here this month are a few selected topics of interest.

PLASMA ENGINE

One area of high interest for some time has been that of plasma physics. It encompasses the technologies of electromagnetics, electronics, atomic physics, and gas dynamics and is also referred to as magnetohydrodynamics. Plasma physics is concerned with plasmas—electrically neutral gaseous mixtures containing electrons and ions.

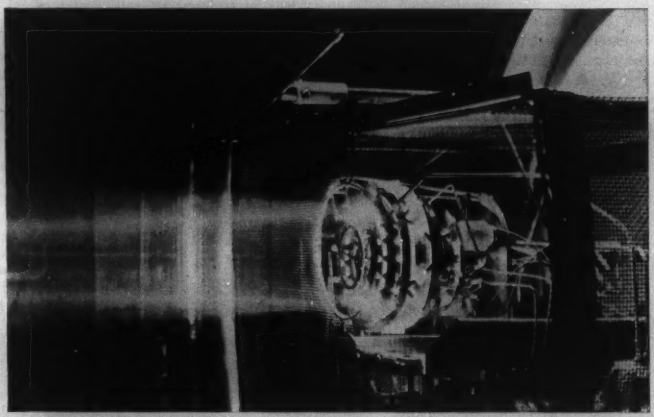
When a gas is ionized it becomes plasma. Ionization splits the molecules and atoms into "free" ions and electrons. A plasma is characterized by the fact that it has electric conductivity, and therefore, can be markedly influenced by outside magnetic or electric fields.

Republic Aviation Corporation, working with plasmas, has announced the development of a lightweight, pinch pulse plasma engine. It obtains its thrust from the magnetic "pinching" of an inert gas such as nitrogen and is capable of operating indefinitely by battery and solar-cell power. The engine meets practical requirements, both for size and weight, for actual space-ship and satellite use. It can be operated continuously in near and deep space for years without needing service of any kind.

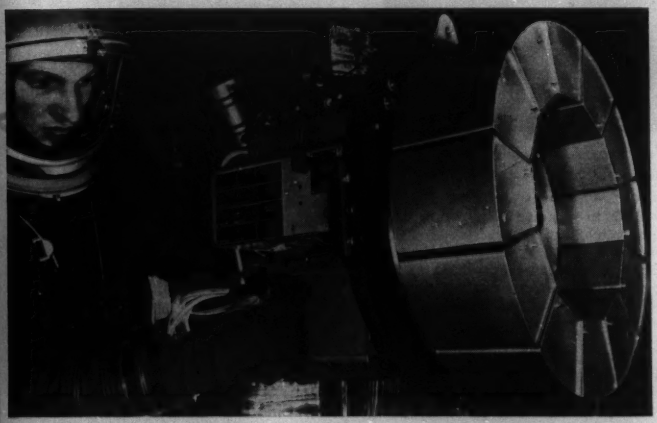
It is said that engines such as the one just announced are needed to propel and "steer" space ships from planet to planet with pinpoint accuracy. Other uses include control for reconnaissance and communication satellites for military and commercial purposes.

The main advantage of the plasma engine over other forms of space propulsion is its light weight due to efficient use of fuel. Its specific impulse, a term used to show efficiency of fuel consumption, ranges from 1,000 to 7,000 seconds. By comparison, the specific impulse of a rocket engine is on the order of only 300 to 500 seconds. This means that the plasma unit has the ability to operate over a much longer period.

The pinch plasma engine uses readily available inert gases for fuel. The fuel becomes ionized after injection into the engine and the resultant plasma is electromagnetically accelerated and exhausted out the nozzle at extremely high velocities. It is the high velocity of the excited plasma which results in the unique, economical use of fuel. Exhaust gas velocities of over 100,000 miles per hour and ejected gas temperatures on the order of 200,000 F have been measured on the new engine.



Glow of ionized atoms is visible shooting out of a working ion engine in a space simulation chamber at Hughes Aircraft Company's research laboratories in Malibu



Technician in a Republic Aviation environmental test chamber makes final instrumentation adjustment prior to test run on new plasma space engine. It is designed to operate on batteries recharged by solar cells

ION ENGINE

Hughes Aircraft Corporation has also announced results of experimental work with electric propulsion in unveiling a model of an ion engine. The propellent used is cesium because it is more easily converted into ions than any other chemical element.

The propellant is stored in a reservoir from which cesium vapor is diffused through a hot tungsten element which, through a process known as contact ionization, ionize's the cesium. A system of electrodes follows, to which voltage is applied in order to accelerate the ions to a very high exhaust velocity. This high-velocity beam passes through a neutralizer region in which electrons are injected into the ion beam to provide space-charge neutralization of the electric field associated with positive cesium ions.

In describing the ion engine, Dr. M. R. Currie of Hughes said:

"It is necessary to emit electrons at exactly the same rate as ions from the vehicle in space because, if only positive ions were ejected, the vehicle

would charge up negatively until it pulled the ions back to the ship. Moreover, it is necessary that the electrons be intimately mixed with the positive ions very close to the vehicle to produce equal positive and negative charge densities everywhere in the beam. If this detailed space-charge neutralization is not achieved, the thrust can be reduced significantly by beam divergence and by return of the beam to the vehicle."

It is anticipated that the ion engine will be tested in a flight of about 1 hour's duration sometime in 1962. The primary source of energy for the ion engine in outer space will be a nuclear reactor. Energy from the reactor will be converted to electricity through a combination of a heat-exchanger and an electric generator.

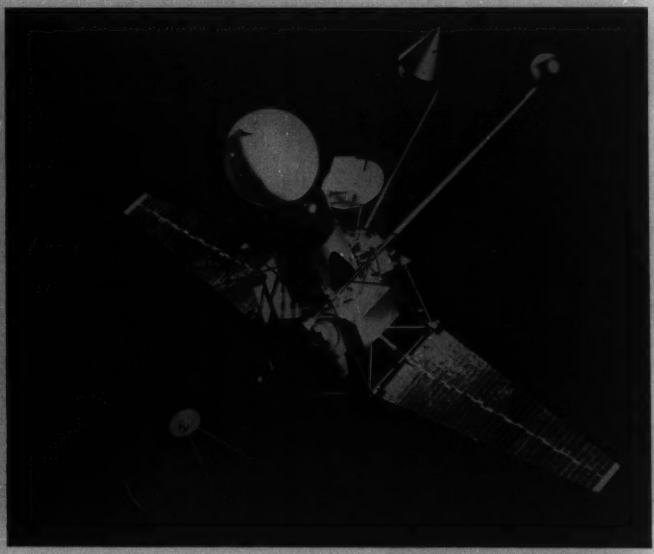
MOON CAPSULE

Ford Motor Company's Aeronutronic Division is developing a capsule which is expected to be landed on the moon's surface sometime in 1962. Purpose of the capsule is to transmit back to earth scientific data about the lunar structure. The capsule will contain a seismometer to record moon quakes, temperature recording devices, and other measuring instruments.

At a distance of about 20 to 25 miles from the surface of the moon, the capsule will be detached from the Ranger spacecraft (under development at Jet Propulsion Laboratory) and a retrorocket will slow its speed to impact the surface of the moon at less than 150 miles per hour.

The capsule measures 25 inches in diameter and consists of a thick outer shell of balsa wood. Inside the balsa-wood shell is a sphere containing the instrumentation. The sphere is surrounded by a flotation fluid, or liquid, to help distribute the structural loads of the lunar impact. This also permits the sphere to right itself to a vertical position by moon-gravity after the assembly comes to rest, so that the sensitive axis of the seismometer is in correct position to transmit its data back to earth.

A near-constant or even temperature for the survival equipment is provided by use of cryogenic-type vacuum insulation and a small quantity of water ballast. The capsule must withstand the environment of the moon where the surface temperature drops to −250 F at night and rises to as much as +220 F during the lunar day.



Components of Ranger spacecraft being built by Jet Propulsion Laboratory including Aeronutronic's lunar capsule portion

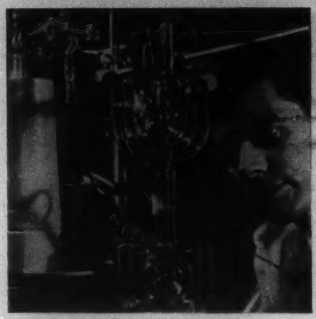
VACUUM EFFECTS ON SPACE VEHICLES

A space environment research program under way at Hughes Aircraft Corporation has brought to light new and perplexing problems with which engineers will have to contend when designing equipment to operate in space.

Metal evaporation studies show that whole sections of a space vehicle might disappear during an extended space voyage if the wrong metal is used in its construction. Some specific problems being studied are:

1. Grease and other lubricants vaporize in ultrahigh vacuum, and a machine that runs smoothly on earth would grind to a halt in space as its bearings dry up and seize.

2. Cold welding of metals in contact with each other becomes a fact in a matter of days in absence of air. The phenomenon, due to molecular attraction, occurs after evaporation of layers of absorbed gases and impurities which coat all materials in atmosphere. Bare atom can then contact bare atom and metals attract to each other as securely as a welded joint.



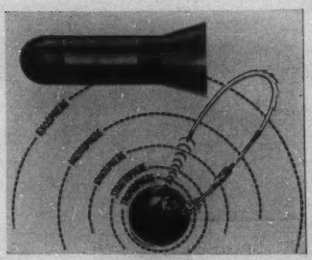
Vacuums greater than those found in the nearly airless void of the moon's "atmosphere" are produced on apparatus such as this at Hughes Aircraft Company

3. Some tough plastics, such as vinyl, grow brittle and lose strength as a result of evaporation of their plasticizer. In other cases, high vacuum protects plastics. Teflon, for example, crumbles to powder when exposed to radiation in the earth's atmosphere, and had been thought unsuitable for use in space. When, at Hughes, irradiation was performed in ultra-high vacuum to simulate a realistic space environment, it was found that Teflon retains its strength and is, in fact, an excellent material to use in space.

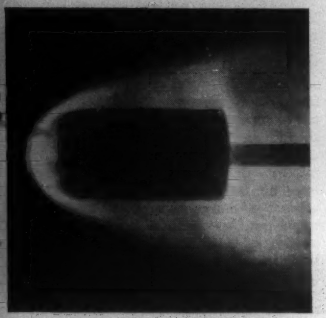
4. Micro-organisms die if exposed to ultra-high vacuum for periods of 20 to 30 days, indicating that the costly practice of sterilizing the exterior of spacecraft prior to launch to avoid contaminating other planets may not be necessary. These findings also argue against the theory that life may have been brought to earth in the form of free-floating spores from outer space.

RE-ENTRY COMMUNICATIONS PROBLEMS

Scientists of Sylvania Electric Products, Inc., are simulating the re-entry of space



Communications with an actual re-entry vehicle is shown with the test projectile used in the Sylvania test program appearing at top left



Simplified nose cone shape burns its way through a 280,000 mph shock wave at Lockheed. High-speed gas flow is from the left side of the illustration

vehicles into the earth's atmosphere at altitudes of 20 to 60 miles. The simulation is part of a study into the effects of the flow of ionized gases around re-entry vehicles' nose cones upon radio transmission to and from such vehicles.

The study, being conducted with the Canadian Armament Research and Development Establishment, simulates re-entry conditions by firing small free-flight models of re-entry vehicles from a "light gas" gun at speeds up to 21,000 feet per second. They are launched into an evacuated tank containing air pressure typical of the earth's upper atmosphere.

HIGH-SPEED GAS RESEARCH

Using a low-cost, all-glass shock tube, research scientists at Lockheed Missiles and Space Company have conducted laboratory tests of spacecraft re-entry at speeds nearly 200 times as great as the swiftest jet fighter. The glass tube generated shock wave speeds of Mach 400 (280,000 miles per hour) and above.

The use of glass permits direct observation and allows photographic study from any angle of shock-heated gas radiation patterns. Time exposures can be used to record the entire event, or high-speed cameras can record various phases of the wave impact as it passes over scale-model re-entry vehicles of various shapes.

The electromagnetic shock tube has its own separate capacitor storage bank capable of storing 60,000 joules of electrical energy. The tube has an inside diameter of 6 inches and a length of 10 feet. Ordinarily it is operated with an initial pressure of 100 microns. The shock wave is driven by the Lorentz (electromagnetic) forces generated by discharge of the tube capacitors. Gases in the tube can be air or nitrogen.

LUNAR MANIPULATOR

Design studies at General Mills established the feasibility of a manipulator designed to operate in outer space. As a result, the firm has delivered a remotely controlled manipulator which can operate on the surface of the moon.

The manipulator was developed to investigate some of the problems and techniques involved in manipulation of remote equipment which might be landed on the moon. Once the landing has been made, the manipulator and vehicle might be controlled from earth by radio signals. The first experimental manipulator is designed to handle a television camera.

Subsequent units might be capable of performing a number of additional tasks such as picking up and helping analyze samples of the moon's crust and aiding in other scientific work. Technology gained in developing the lunar manipulator will also be applicable to other manipulators for use in space and for planetary landings. These might be used for both external and internal repair of satellites.

SATELLITE RECOVERY SYSTEM

A method to control, maneuver, and land a satellite in a predetermined area by varying the vehicle's aerodynamic shape in flight is under study at Avco-Everett Research Laboratory. By altering the satellite's aerodynamic drag area, Avco scientists hope to use aerodynamic forces to provide both lift and drag for satellites in orbits up to altitudes of 150 miles. Such control would make it possible to change the re-entry trajectory in or out of the plane of orbit, thus maneuvering during descent to land at a preselected area. The system would also limit the deceleration and heating of re-entry.

Two Firms Develop Wire for Superconducting Magnets

Two of the nation's largest manufacturers in the electrical-electronic industry have announced development of processes for producing wire for superconducting magnets. Such magnets show great promise for a variety of industrial and military electrical applications.

Scientists at the Westinghouse Electric Corporation's research laboratories have developed a superconducting magnet that for its size, weight, and energy consumption is said to be the most powerful magnet ever built. The size of a doughnut and weighing only one pound, the magnet creates a magnetic field twice as strong as that from a conventional iron-core electromagnet as large as an automobile weighing 40,000 pounds and operated to saturation of the iron. Such a conventional iron-core electromagnet needs its own power plant to supply continuously the 100,000 watts or more of power to run it.

The new superconducting magnet runs from an ordinary automobile storage battery which supplies only a few watts of power to overcome the small losses in the wires leading to the magnet. It is wound from a wire which is a superconductor—a material which loses all electrical resistance at temperatures near absolute zero. Once started, supercurrents of electricity flow through superconductors forever without loss in strength.

For its size, weight, and energy consumption, this small coil of superconducting wire is said to be most powerful magnet ever built

The superconducting magnet developed by Westinghouse contains a half-mile of niobium-zirconium base alloy wire. About 5,000 turns of the threadlike wire are wound into a coil, or solenoid, 2 inches in diameter and 1½ inches long. The coil is immersed in a vessel of liquid helium which keeps it at a temperature near —450 F. Although only three times the thickness of a human hair, the wire from which the coil is wound carries a current of 20 amperes. The magnet produces a magnetic strength, or flux density, of 43,000 gauss.

Scientists at the Radio Corporation of America, it has been announced, have developed a simple chemical method for rapid and continuous growth of crystalline niobium-tin, a compound superconducting material. The laboratory equipment involved is capable of producing uniform crystal coatings of niobium-tin on a fine wire at the rate of 30 feet per hour. Production refinements in the future are expected to increase this output rate greatly.

Tests on short-wire lengths performed at the Lawrence Radiation Laboratory, University of California, Berkeley, indicated that the wire remains superconductive in 94,000-gauss magnetic fields, while supporting a current of 7 amperes. This represents a current density in the superconductive coating of 100,000 amperes per square centimeter. The tests demonstrated the feasibility of winding the wire in any desired lengths to form extremely powerful magnets without the danger of the wire cracking or otherwise losing its useful properties.

Development Work Under Way on New Power Sources

Research scientists at Allis-Chalmers Manufacturing Company report that they

are now using ammonia as a fuel in the company's fuel-cell development program.

In a report presented at a recent meeting of the American Chemical Society, it was stated that advantages of the ammonia fuel cell are that ammonia is low in cost when purchased in large volume; is easily condensed, and that storage, transportation, and handling techniques have been worked out for ammonia used in large quantities.

The laboratory-sized ammonia fuel cell uses electrodes of porous carbon. A catalyst of platinum black applied to the electrodes aids the reaction. An electrolyte of concentrated potassium hydroxide is held in a porous diaphragm between the electrodes. Ammonia is fed to the anode side of the cell and oxygen to the cathode side. The resulting chemical reactions cause an electric current to flow between the electrodes in an external circuit. The principal products of the reaction are nitrogen and water.

Atomics International, a division of North American Aviation, Inc., has been awarded a study contract by the Army Signal Corps for a "back pack"-sized power supply to generate electricity directly and to operate on conventional fuels. The contract calls for a 1-year research and development study in three technical areas—thermionic converters, heat sources, and high-temperature materials.

Direct conversion devices are attractive for military use because potentially they are lighter and can operate longer than conventional batteries. They need not be recharged or replaced and can be refilled with readily available fuel.

New Television Tube Has No Horizontal Lines

Usual horizontal scanning lines are eliminated in a new kind of television picture tube displayed recently at the Berlin Fair by Westinghouse Electric Corporation. The tube was mounted in a special television set made by a major German electronic equipment company.

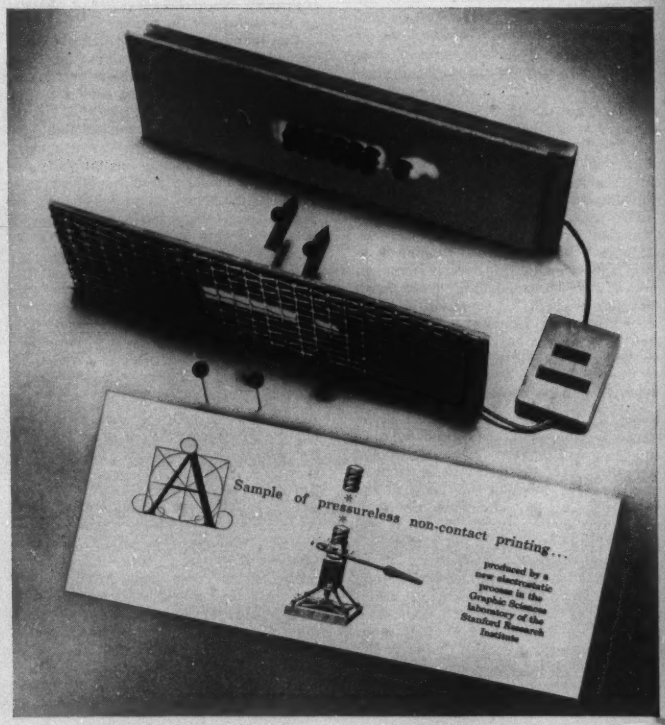
The new tube eliminates the usual scanning lines by subjecting the electron beam to a small-amplitude, high-frequency deflection, thus enlarging it vertically to fill in the conspicuous black areas between the information lines. An oscillator's output is used to deflect the scanning spot so that it moves up and down in a sinusoidal path instead of tracing straight across the tube. If a high enough frequency is used, the individual oscillations crowd together and give the impression of a thicker line rather than just discrete cycles of oscillation.

A split-focus grid device is used with the tube. Separate leads from each half of the split electrode are brought out through the base of the tube for connection to the oscillator. Acting as a single unit, the two halves of the focus electrode continue to control focus in the conventional way; but acting as separate units they form a push-pull pair to swing the beam rapidly up and down.

Electrostatic Printing: A Workable Technique for Soft Surfaces

Applicable to fragile, soft, or irregular materials, a printing technique known as electrostatic printing or pressureless printing shows promise for broadening the variety of useful printing surfaces beyond what has been previously possible.

Described in the September-October 1961 issue of *Research for Industry*, a publication of the Stanford Research Institute, the printing technique was developed by Stanford under sponsorship of the Electrostatic Printing Corporation of America. Clean, sharp images can be printed on such varied materials as low-grade newsprint, sandpaper, glass, corrugated cardboard, rolled cotton, and aspirin tablets.


Sample of pressureless non-contact printing...
produced by a new electrostatic process in the Graphic Sciences laboratory of the Stanford Research Institute

Model of ink passing through masked screen of electrostatic printer developed at Sanford Research Institute

MODEL OF EQUIPMENT

A model of the equipment used is shown in the accompanying illustration. A 200-mesh stainless-steel screen is charged to about 1,500 volts. A stencil in which the image area is transparent and the nonimage area is opaque is applied to the screen. The material to be printed is placed behind the screen. Backing up this material is a solid metal plate of opposite polarity from that of the screen.

A rotating brush is used to brush a mixture of dry-ink pigment and resin into the screen. The dry-ink particles acquire a charge. The rear electrode attracts the charged ink particles and those in the transparent areas of the image pass through to the paper. By application of heat, the dry-ink and resin image is fixed firmly and permanently to the paper being printed.

Although currently experimental, the electrostatic printer is capable of high-quality reproduction. The 200-mesh screen could mean easy and inexpensive reproduction of 200-screen halftones. Greater control of the printing process compared to conventional techniques is also possible. For example, optical density of the ink could be varied by changing the level or duration of the voltage. In addition, it will be possible to print both sides of the paper simultaneously since the ink-and-resin particles can be charged to either polarity.

Navy Reveals Details of ASROC Trainer

The necessity for training Navy missile men to wage realistic practice battles with enemy submarines has been met at Norfolk Navy Base, where the men are trained on shore without ships, missiles or submarines. The ASROC antisubmarine weapons system features a trainer consisting of a number of electronic consoles that simulate the equipment used aboard ships to locate and track enemy submarines, compute their course, range, and speed, aim the ASROC launcher, and fire the missiles.

A variety of electronic systems simulating actual battle conditions give the sonar, computer, fire control, and launcher consoles of the trainer opportunity to perform as if they were in operation aboard ship. Engineers describe the trainer as a synthesized operational ASROC system with the same external appearances and functional features of the actual equipment.

Operation of the trainer is a combined effort of the instructors and trainees. The tactical situations are established, monitored, and controlled by instructors at a master console. The trainees at various stations manually operate simulated components of the ASROC system to perform functions required during actual tactical situations.

According to Navy officials, missile crews can learn the intricacies of the ASROC system and become professional in its operation before ever seeing a shipboard installation, which offers a significant saving in both time and money.

The basic elements are:

Instructor's projection room, which includes a screen and projection system which displays movement of all ships and targets, and the instructor's console, from which the action of the entire trainer can be started, monitored and stopped. In effect, the instructor has complete control of the type, complexity, length and conduct of the problem. He represents the enemy since he controls the two target submarines.

ASROC ship mockup of underwater battery plot, which contains simulated sonar, computer simulator and missile flight simulator, the attack console, plan position indicator, target course indicator, and ASW contact alarm.

ASROC ship combat information center mockup, which has a dead reckoning tracer; air, surface and ASW plotting boards; and ASW contact alarm.

ASROC ship conning station mockup, including helm and position generator, wind repeater, position indicators, and radar simulation.

ASROC ship launcher control station mockup, which is the launcher captain's control panel simulating actual launcher response and the ASW contact alarm.

Two support units, consisting of help and position indicators, an instrument board, a dead reckoning tracer and surface summary plot. The bridge and CIC of a support vessel are simulated.

Minneapolis-Honeywell's Ordnance division facility at Duarte, Calif., built the trainer.

Modern drive-in banking equipment at First National Bank of Waukesha, Wis., combines closed-circuit television and pneumatic tubes

Speed-Up Accomplished in Drive-In Banking Transactions

The latest refinement in drive-in banking combines electronics and pneumatics, and allows teller and customer to talk to each other and to see each other while exchanging documents or money. International Telephone and Telegraph Corporation announces its new Autobanker installation at the First National Bank of Waukesha, Wisc., as a system employing closed-circuit television, high-fidelity audio, and a new type of pneumatic tube, functionally integrated to permit customers to complete bank transactions from the front seat of their automobiles.

The Autobanker accommodates every customer service normally handled by a teller—the teller in the heart of the bank, and the customer perhaps 600 feet from it. The customer unit consists chiefly of a television screen, camera, microphone, and pneumatic tube station. Equipment at the teller's cage is essentially the same, plus simple controls which dispatch or recall the carrier and open a door at the customer end of the tube.

The pneumatic tube carrier, designed by ITT's Airmatic Systems Corporation, is "captive" at the customer terminal. When the teller sees the light indicating that the carrier has arrived at the customer unit, she depresses a switch opening a little access door. Simultaneously, the side of the carrier springs open, permitting the customer to place bank books, checks, cash, or rolls of coins into the carrier.

The teller, viewing the customer and conversing over the intercom, then closes the door, recalls the carrier and completes the transaction, usually in less than a minute. The motorist follows the teller's activities on the outside monitor.

Pressure and vacuum for the carriers are provided by blowers in the basement of the bank; the carriers, 13 inches long, 7 inches wide, and 4 inches deep, permit control of the access door from within the bank. Up to 3½ pounds of material may ride the tubes at a speed of 25 feet a second. The oval tubing can negotiate a 90-degree turn in a radius of 48 inches.

The Autobanker should be useful in downtown banks beset with parking and traffic problems, and at shopping center banks where customers prefer to remain in their cars while transacting business.

The stainless steel customer units at Waukesha are under cover, but Autobanker units are fully weather-proofed, and equipped with thermostatic controls and heaters for unattended service in direct exposure to the elements.

Laminated Plastic Structures Support Huge Transmitter Parts

On the rocky coast of Maine, the U. S. Navy has installed a powerful 14- to 30-kc radio transmitter for world-wide communication with surface ships, shore stations, and submerged submarines. An interesting aspect of the construction of

Variometer and helix coil supports for Navy transmitter are made from laminated plastics

the station was the abundant use of laminated plastics.

In the illustration on page 877, a variometer and helix coil supports are shown. These are made from laminated plastic by Permali, Inc. The helix coil structure supports over 12 tons of cable without using a single metal fastener, laminated-plastic nuts and bolts are used throughout.

The variometer has a rotor made by Permali which carries about 4,000 pounds of cable and is designed for negligible angular distortion in operation. The stator is wound with 5,000 pounds of cable and the whole structure is nearly 22 feet high, 13 feet long, and 12 feet wide.

Yale Dedicates Million-Dollar Atom-Smasher

Colleges and universities are falling into line with the accelerated programs of scientific research throughout the country. After more than 3 years of planning and construction, Yale University's new million-dollar electron linear accelerator is now operating.

The atom-smashing machine, financed by the U. S. Atomic Energy Commission, was dedicated in New Haven on September 14. Professor of Physics Howard L. Schultz states that the linear accelerator, or LINAC, will provide Yale scientists with a tool to attack key problems of the structure and nature of atomic nucleus. Basic research will proceed on photonuclear reactions, nuclear structure, studies through neutron bombardment, and high-energy electron scattering.

The accelerator operates normally at 40,000,000 electron volts but at smaller currents the beam energy may exceed 80,000,000 volts. It accelerates over 25 kw of electrons down a 45-foot copper tube to bombard nuclear targets in pulses of a few microseconds.

The machine is housed in Yale's Accelerator Laboratory on Pierson-Sage Square where extensive construction work has been completed for underground tunnels and work space. The "hot" chambers of the linear accelerator, deep in the hillside, are shielded by concrete and earth filling.

When the machine is in operation, instruments recording the bombardment are observed by Yale scientists through closed-circuit TV at control panels in another part of the laboratory.

The LINAC was designd and built by the Applied Radiation Corporation of Walnut Creek, Calif., a subsidiary of High Voltage Engineering Corporation of Burlington, Mass. It uses giant radio-frequency power tubes to give electrons a series of "kicks" along a straight line. The pulses of electrons emerge at up to 80 million volts with enough energy to cause nuclear reactions in all elements.

The LINAC (replacing an older one which has been dismantled) operates on the "L" band microwave frequency which yields a very high-peak r-f power and, consequently, high quantities of radiation in a single pulse. Such powerful pulses, heretofore unknown, are desired for neutron time-of-flight investigations and other experimental work.

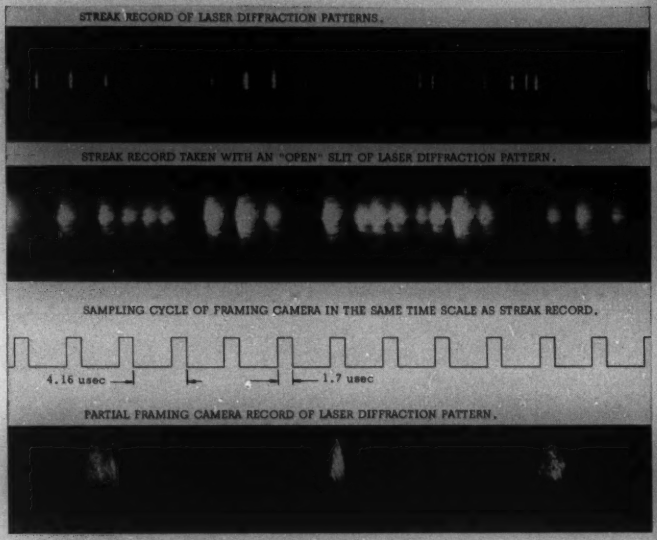

STREAK RECORD OF LASER DIFFRACTION PATTERNS.
STREAK RECORD TAKEN WITH AN "OPEN" SLIT OF LASER DIFFRACTION PATTERN.
SAMPLING CYCLE OF FRAMING CAMERA IN THE SAME TIME SCALE AS STREAK RECORD.
4.16 usec
1.7 usec
PARTIAL FRAMING CAMERA RECORD OF LASER DIFFRACTION PATTERN.

Photo recordings of laser outputs by Beckman and Whitley, Inc., are explained in text

High-Speed Photographs Document Laser Operation

Using a framing camera capable of taking discrete pictures at framing rates up to 4.3 million per second and a sweeping-image camera, scientists at Beckman and Whitley, Inc., have made a series of laser photo recordings. The accompanying illustration shows several of them.

The upper recording is a sweeping-image picture of a ruby 2 inches long by ¼ inch in diameter excited by a Edgerton, Germeshausen and Grier, Inc. laser-stimulator system. The input was 980 joules and the observation period was delayed 400 microseconds after the start of the input pulse to allow for laser induction time. This record is a plot of angular beam width vs time for a single line through a diffraction pattern produced from the laser, accomplished by focusing the laser output on the slit of the sweeping-image camera. Computations of the beam width of the laser output can be made readily from this type of record. Bright streaks represent individual bright spots in the face of the emitting ruby.

In the center is shown another sweeping-image record, differing from the previous one in that the slit was removed from the camera and the record therefore showed the entire diffraction pattern image. Even though some bursts are more intense than others, an essentially repetitive pattern is shown. This pattern indicates that emission from the ruby face occurs in a manner related to the irregular characteristics of the surface.

Observation of output from the same laser by framing-camera techniques removes the streaking and overlapping character of the center illustration and is shown in the lower recording. Careful choice of a framing rate of 240,000 exposures per second or 4.16 microseconds between frames, and an exposure time of 1.7 microseconds provided the optimum combination of a high probability of exposure synchronization with laser action on some frames. It also provided a low probability of exposing any frame to more than one burst, since the mean frequency of the laser was 300,000 bursts per second.

Electrical Storms May Affect Human's Mental Health

Research on the causes of mental disease and on contributing factors is an increasingly important field of investigation. On the basis of a study of environmental factors—the magnetic fields around us and our electrical interaction with them—it has been suggested that an electrical charge in human beings may affect their mental health and general well-being.

The number of patients admitted to hospitals for psychiatric disturbances is related to an increase in the number and intensity of electrical storms, scientists and engineers meeting at the second annual Bionics Symposium at Cornell University were told by Dr. Robert O. Becker. His paper revealed that all nerve cells are electrically polarized, that is, one end is positive and the other negative, and that there is a constant electric current flowing within the nerve and its fibers, which is thought to be produced by the flow of electrons moving within the molecular structure of the nerve in the same fashion as within transistors or

other similar solid-state devices. Changes in the amount of current or the polarization potential change the way in which the nerve fiber functions. For example, dropping the current to zero or reversing the polarization produces in the nerve fiber a state of inactivity.

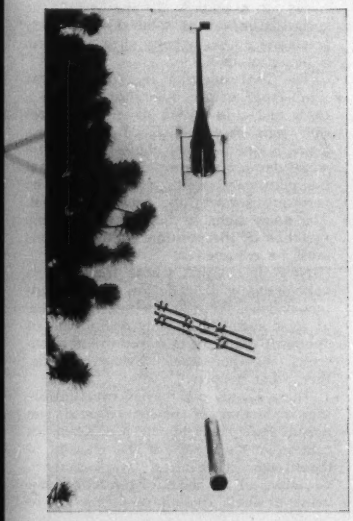
Preliminary research has shown that the electric charge in humans varies in a 24-hour period and a longer period of about 28 days. The mentally ill person shows the same pattern, but with greatly exaggerated variations and in an opposite direction. This cyclical variation is similar to such cycles in nature as that of the mussel, which opens and closes with the tides even when not near the shore, and it may have applications to the adjustment of astronauts to space travel, where the biological clock will be affected.

Research shows that the electrical charge of a person's body changes drastically when he is under hypnosis or anesthesia. Any injury or abnormality affects the normal pattern of charges, a phenomenon which may have applications in treatment of wounds, tumors, cancers, and mental illness, in the regrowth of limbs, in the use of hypnosis in medicine, and in many other areas of life.

Perhaps the most dramatic possibility is that our behavior and moods are influenced in part by the electromagnetism of our environment. Dr. Becker and his associates have found that the number of patients admitted to hospitals for psychiatric disturbances correlates with the magnetic index of the environment the previous day and with solar flares three days before.

Telephone Line Built 30 Times Faster by Helicopter

Building telephone lines in rough terrain sometimes presents seemingly insurmountable difficulties. Pacific Telephone recently invaded the wilderness east of Spokane to relocate long-distance telephone lines in the Bitterroot Mountains of Idaho. The job was to build a 40-pole stretch on 40- to 50-degree slopes in mountains almost a mile high and in dense forest growth. It was decided to build the 3-mile section by helicopter.



According to the engineers, the work was completed 30 times faster than it would have been by conventional methods. First, ground crews scrambled along the right of way, blasting holes in the rocky slope. At the two staging areas selected for heliports, phone company crews fixed crossarms and insulators to the poles and rigged-up slings, some of which were 80 feet long. Actual placement flights at 40 miles an hour extended from a few hundred yards to 1½ miles. The Hiller 12E, by Evergreen Helicopters of McMinnville, Oreg., weighing only 1,750 pounds, lifted straight up the fully fixtured poles which weighed up to 900 pounds. Because the thick forest necessitated extra long slings from the poles, the helicopter was never close enough to the ground, when hovering to lift or lower the poles, to take advantage of "ground effect" (the returning cushion of downwashed air that acts as a booster).

The helicopter, lifting the 900-pound poles, hovered motionless as it zeroed in for the planting. Two men assisted at the heliport, and two at the lowering of the pole to the ground; another guided the pilot. Total flight time for all 40 poles was under 4 hours, with the balance of the 8-hour project given to preparation and stand-by. Once all the poles were placed, two runs were made along the line to lay two manila lead lines for stringing operations to follow. Flight time for this capping-off operation—12 minutes.

Despite the problems and difficulties of the wooded slopes, the job was considered as one of the smoothest in the company's history. According to phone company officials, in addition to the astonishing saving in time, the dollar savings were substantial.

Cooper Union Opens New Engineering Building

An urgently important function in today's education is keeping up with fast-moving progress and change. As a contribution to modern educational effort, Cooper Union in New York City is initiating a detailed study to reassess its present program in preparing engineers for successful service. Expansion and reorientation are expected in the curriculum as a result of the study.

Attendant upon this development, a new building has been recently completed for the Cooper Union School of Engineering at Fourth Avenue and Astor Place. The building contains facilities for present programs in engineering instruction and potentials for future needs. At its opening in September, Dr. Richard G. Folsom, president of Rensselaer Polytechnic Institute, in his dedicatory address said, "The engineering profession is progressing so fast that the rate of obsolescence of engineering knowledge is estimated at about 5 per cent a year . . . an engineer merely practicing his profession and not engaging in continuing learning and study, in 10 years would have only 50 per cent as much knowledge as he needed." Dr. Folsom believes that research and practicing engineers can serve as adjunct faculty members or as student members of a class, that they can aid and supplement the work of the regular faculty, so that people from the various segments of the profession may teach and learn from each other, and the decay of professional development can be halted. Dr. Folsom said, "It is entirely possible that the lights in engineering evening classrooms will illuminate a new era of progress for mankind."

The new building seems a fitting and practical monument to these high aspirations. It is a 6-story structure that provides about 100,000 square feet of space, and contains 25 laboratories, shops, and drawing rooms, and 22 classrooms. One of its features is the arrangement on the same floor of related laboratories, classrooms, and offices for each of the science and engineering fields. The cost of its construction and equipment was about $4,750,000.

Automatic Road Paver Lays Perfectly Smooth Mats

Automatic 2-axis control of grade and slope is provided by a new control system for road pavers. Developed by Minneapolis-Honeywell, the new system is said to enable road pavers to lay perfectly smooth mats automatically, regardless of rough or irregular roadbeds.

The system can be installed on new pavers and retrofitted on used models. Operating controls are simple. The operator merely dials slope and grade corrections and then throws two switches to the automatic setting.

SYSTEM OPERATION

The paver control consists of six components: a command panel, pendulum, grade sensor, control box, and two servo motors or hydraulic pistons, one on each

Two dials for grade and slope plus two switches are the only controls that must be set by the operator of a Minneapolis-Honeywell road-paving control panel

side of the paver. The command panel, sensor, and pendulum feed electrical signals which are based on desired and existing grade and slope, into the control box. Using these data, the control box electronically controls the servo motors or hydraulic pistons to vary the screed attack angle, automatically compensating for any road irregularities that may occur in the paving process.

A true horizontal reference is provided by the pendulum. Fastened to a transverse beam attached to the tow arms on either side of the paver, the pendulum is a cylinder floating in a silicon oil. Because it is actually buoyed up by the oil, the pendulum is free-floating, thus providing precise control and virtually eliminating friction.

The sensor measures desired grade. A grid attached to the sensor rides on the reference string, or the sensor can be equipped with a ski to ride on existing pavement.

The new control is being checked out on a stretch of Interstate Highway 80 in Iowa. Highway Surfacers, Inc., is laying 400,000 tons of high-type asphaltic mix to a depth of over 20 inches on an 8-mile stretch of 4-lane highway. A Cedarapids paver equipped with the new control is laying 600 tons of asphaltic concrete an hour.

LETTER TO THE EDITOR

To the Editor:

The notes which follow discuss the controversial subject of minimum useful level for electromagnetic signals. I personally feel that it is important in the interests of technological advancement that the subject be discussed and resolved, since questions raised can have a very strong bearing on the development of both civilian and military communication systems. It is hoped that this material will provoke thought and discussion.

In the radio spectrum between 100 and 1,000 mc, the minimum signal level which can be received effectively—that is, which can have useful information extracted from it—might appear to be limited only by thermal noise. There is, however, considerable evidence indicating that the contrary may be true.

The first important fact tending to indicate that a minimum must exist is the photoelectric phenomenon. Experiment has shown conclusively that regardless of how weak a light beam falling on a photocell may be, if the photocell is sensitive to the light, emission occurs at irregular intervals. This means that in some way enough energy is concentrated on a single electron to cause ejection, even though the average intensity over the photocell surface may be so small that collection of sufficient energy for ejection from the impinging wave motion might take days or years.

Einstein showed that it was the vibration frequency of the light, not the intensity, which governed emissions. He showed that the frequency of the light or electromagnetic radiation must be sufficiently large that $h\nu > E_0$, where h is Planck's constant, ν is the vibration frequency, and E_0 is the work function of the photoelectric surface.

Now, E_0 has the dimensions of energy, whereas energy flow in the light beam has dimensions strictly of energy per unit time, as it must if a continuous stream of energy is transmitted. Hence, the energy flow will be defined in terms of an equation of the form

$$P = dE/dt = h\nu N/t \qquad (1)$$

where N/t gives the number of photons per second radiated by the source passing a given observation station. But the frequency ν is a number of events per second, with result that the equation for P may also be written in the form

$$P = kh\nu \qquad (2)$$

where $N/t = k\nu$

The question now is, "What is the value of k?"

In order to obtain some ideas on the limits for the value of k, Lawrence and Beams[1] attempted to measure the duration of a photon by generating the shortest possible pulses of light in an attempt to "cut a photon in half." Their conclusion was that the length of a photon was at least shorter than centimeters (10^{-9} second), as they were unable to detect any evidence of slicing whatever. Consequently, the length of a photon must be less than a few thousands of wavelengths, and it might be as short as a wavelength or less. The probable maximum length is a few hundred wavelengths.

At this point, a "gedankt" experiment might be performed. The question to be answered would be, "Is there any 'most probable' length for a photon?" The photon must behave as a particle, yet it must be capable of developing wavelike characteristics.

If one examines the spectrum of possible waveforms capable of showing both wave and particle characteristics, one must eventually try some form of sampling function in which the energy is concentrated in a wavelength or less. One might conclude from the resulting characteristics that it could well be a probability average for the photon "waveform." And the conclusion would be that in effect the value of k might be in the neighborhood of 0.5 or unity.

At this point, the experiment of Joffe and Dobronravoff[2] is of interest. These investigators were attempting to place limits on the physical dimensions (transverse) of X-ray photons. They floated a bismuth particle in a Millikan condenser near the anticathode of an X-ray tube, and determined that the dimensions of an X-ray photon could not exceed 5×10^{-5} cm, or several wavelengths of visible light. They generated approximately 1,000 photons of X rays per second, and obtained strikes on the bismuth particle approximately once every half hour. The subtended solid angle of the particle was 10^{-6} steradian. The maximum number of strikes they might have expected was one every 100 seconds instead of one every 1,800 seconds.

An additional note may be added on the Joffe experiment. The fact that only one in 20 of the photons potentially penetrating the bismuth particle succeeded in creating a detectable change indicates that the size of the X-ray photon is sufficiently small to pass directly through the particle without impact. This clearly indicates that the lateral dimensions of the photon may be many orders of magnitude smaller than the bismuth particle as a whole. It can be expected to be smaller than the interatomic spaces.

Consequently, although the evidence is by no means incontrovertible, it appears probable the maximum dimensions of the photon are in some way closely associated with the wavelength of the radiation.

The next question is "What is the significance of this in the uhf portion of the radio spectrum?" If one assumes that the value of k is approximately unity for normal-intensity radiation, then one can place a floor under the "minimum receivable" signal. There are two diametrically different cases: reception of "white noise" signals and reception of narrow-band, or line-spectrum, signals.

With white, or random, noise, one broadens the receiver spectrum bandwidth until a steady noise signal is obtained, and then measures its minimum detectable value. Curiously, data given the writer on conditions at 400 mc by research workers at Ohio State University and at 1,500 mc by workers at Harvard Radio Observatory *both* indicate minimum detectable signals at approximately the levels given by equation 2 for a value of k of unity. The writer calculated the corresponding levels for each frequency based on equation 2, and asked the scientists concerned what the sensitivity levels were. The results checked within a factor of two.

The next question is, "What is the significance of the difference between a noisy and a low-noise signal in connection with photons?" Since a low-noise signal is one in which the random phase variations are minimized, it means that the placement of the photons must be very precise with the low-noise signal. The noisy signal is one in which some variation of the positions of the photons must be expected.

Now, if a signal whose frequency is very precisely defined (low noise) is attenuated by transmission through space, at some signal level, only one stream of "photons" will be received by the antenna. As the signal is weakened further, what happens?

There is only one way in which a further reduction of power received can occur, and that is by the process of reception of only part of the photons in the stream. Propagation vagaries, microvariations of the index of refraction, can cause a small amount of wandering to

occur in the flow of photons, with the result that some of the photons in the stream will miss the collecting antenna completely.

This variation, or wandering, in the flow can introduce small perturbations in the arrival time of the individual photons which are captured, and will introduce phase noise into the received portion of the signal. The result is a loss of information and a broadening of the signal bandwidth.

Bolgiano and Gottschalk[3] have shown theoretically below the energy level which represents the minimum complete received signal, the utility of the received signal decays quite rapidly and, although the presence of a signal may be detectable to as much as several (2 to 3) decades lower power level, the difficulty of extraction of useful information such as signal frequency rises rapidly as the level decreases. Report *ORD-27* lists some 58 papers and references, some of the more important being:

Science and Information Theory (book), L. Brillouin. Academic Press, Inc., New York, N.Y., 1956.

The Question of Correlation Between Photons in Coherent Light Rays. *Nature*, London, England, vol. 178, 1956, p. 1447.

Theory of Communication, D. Gabor. *Journal*, Institute of Electrical Engineers, London, vol. 93, 1946, p. 429.

Communication Theory and Physics, D. Gabor. *Philosophical Magazine*, London, vol. 41, 1950, p. 1161.

Lectures on Communication Theory, D. Gabor. *Lecture Notes*, Massachusetts Institute of Technology, Cambridge, Mass., Fall 1951.

Der Nachrichtengehalt eines Elektromagnetischen Signal, D. Gabor. *Archive der Elektrischen Ubertragung*, 1953, p. 95.

Quantal Aspects of Scientific Information, D. M. Mackay *Philosophical Magazine*, vol. 41, 1950, p. 289.

On the Average Volume per Photon in Black-Body Radiation. *American Journal of Physics*, New York, vol. 25, 1957, p. 117

Sincerely,
Keats A. Pullen, Jr. (F '61)
Ballistic Research Laboratories
Aberdeen Proving Ground, Md.

REFERENCES

1. *Physical Review*, New York, vol. B-2, 1928, p. 478; *Journal*, Franklin Institute, Philadelphia, Pa., vol. 206, 1928, p. 109.

2. *Zeitschrift fur Physik*, Charlottenburg, Germany, vol. 34, 1925, p. 889.

3. Quantum Mechanical Analysis of Radio-Frequency Radiation, L. P. Bolgiano, Jr., W. M. Gottschalk. Department of Electrical Engineering, University of Delaware, Newark, Del., under Contract no. DA-36-034-509-ORD27.

NEW LIBRARY BOOKS

THE METALLURGY OF SEMICONDUCTORS, Yu. M. Shashkov. Consultants Bureau Enterprises, Inc., 227 W. 17 St., New York 11, N. Y., 1961; 183 pages, 6¼ by 9¼ inches, bound; $9.50. A translation from the Russian, this text deals with the metallurgy of two semiconductor materials, germanium and silicon. The topics dealt with are purification of materials, growth of monocrystals, diffusion of impurities, heat treatment of germanium and silicon, doping methods, production of heterogeneous electrical structures in monocrystals and preparation of ohmic contacts, and etching.

HALBLEITERPROBLEME. VOLUME 5, Fritz Sauter (editor). Friedr. Vieweg & Sohn, Braunschweig, Germany, 1960; 343 pages, 6½ by 9½ inches, bound; DM 48.00. This book comprises a group of nine papers encompassing various aspects of semiconductors, both theoretical and practical. The topics discussed include recent results of infrared spectroscopy of solid bodies, negative effective masses in semiconductors, the behavior of semiconductors in strong magnetic fields, the influence of band structure and electron grid reaction on light absorption in semiconductors, and the maser. The final paper on surface layer development on metals has a long English summary.

LARGE-SIZE PERFECT DIFFUSORS, H. Zijl. Philips Technical Library, Einehoven, Netherlands; second edition, 1960; 196 pages, 6¼ by 9 inches, bound; $4.50. This is a survey of the problems of light distribution for diffuse emitters of both finite and infinite dimensions. Features of the book include a set of 49 charts from which illumination values produced by diffuse light sources can be computed directly, a set of coefficient-of-utilization tables to be applied in computing modern installations for general lighting, and a new method for computing the sky factor in daylight engineering. In addition, a rule of thumb is given for bringing most of the problems relating to large light sources within the scope of the simple inverse square law and cosine law.

ENGINEERING FUNDAMENTALS FOR PROFESSIONAL ENGINEERS' EXAMINATIONS, L. M. Polentz. McGraw-Hill Book Co., Inc., 330 W. 42 St., New York 36, N. Y., 1961; 366 pages, 5½ by 8¼ inches, bound; $9.50. Fundamental engineering principles in mathematics, mechanics, fluid mechanics, thermodynamics, mechanics of materials, electricity and electronics, chemistry, and engineering economics are outlined. Each principle is first explained; then applied to specific engineering problems; finally, problems from past examinations are provided for practice and review. (Answers are at the end of the book, but emphasis is on method and presentation of the solution throughout the book, rather than on the answer itself.)

V D E FACHBERICHTE, VOLUME 21, 1960. VDE-Verlag G.m.b.H., Berlin, Germany, publishers, 1961; various pagings, 8¼ by 11¾ inches, paper; DM 30.00. Of the two groups of papers contained in this volume, 18 are in the field of heavy-current engineering. They are classified under six headings: power distribution, industrial electric heating, current rectification, load distribution and interconnected systems, electrical machinery and drives, and lighting. The remaining eight papers, in the communications field, deal with such topics as transoceanic cables, 3-D radar, ultrashort-wave communications, and teleprinter equipment.

THERMOELECTRICITY: SCIENCE AND ENGINEERING, R. R. Heikes, R. W. Ure, Jr. Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y., 1961; 576 pages, 6¼ by 9¼ inches, bound; $18.50. This book covers the physics and chemistry of thermoelectric materials, the design of materials, and their device technology. Specific aspects considered include classical and irreversible thermodynamic treatment of thermoelectricity, thermal conduction in thermoelectric materials, measurements of properties of thermoelectric materials, theory of thermoelectric materials, low-temperature Peltier cooling, thermionic conversion, theoretical calculation of device performance, and heat transfer problems in thermoelectric devices.

PHYSICAL CHEMISTRY OF MACROMOLECULES, Charles Tanford. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1961; 710 pages, 6 by 9¼ inches, bound; $18. This book presents fundamental theory in the major areas of physical chemistry. The subjects discussed include molecular structure with emphasis on X-ray diffraction, molecular statistics, thermodynamics, light scattering, transport processes and viscosity, electrostatics, and equilibria and kinetics of reactions. Each section modifies or extends the theory to apply it to molecules of very high molecular weight, both synthetic and natural. Fundamentals of macromolecular structure and behavior are presented along with experimental data from the current literature.

ENERGIEBILANZ UND RENTABILITAT VON HEIZKRAFTWERKEN, Herbert Bachl. Springer-Verlag, Berlin, Germany, 1961;

LIBRARY SERVICES

Engineering Societies Library books, except bibliographies, handbooks, and other reference publications, may be borrowed by mail by AIEE members for a small handling charge. The Library also prepares bibliographies, maintains search and translation services, and can supply a photoprint or a microfilm copy of any item in its collection. Address inquiries to R. H. Phelps, Director, Engineering Societies Library, UEC, 345 East 47 Street, New York 17, N. Y.

78 pages, 6 by 9 inches, paper; DM 18. This book gives a detailed treatment of energy balance calculations and the determination of earning capacity of thermal power plants. Open and closed cycle gas turbines and steam plants are considered. Tables, charts, and energy- and heat-flow diagrams are included to illustrate or summarize the calculations.

ELECTROMECHANICAL SYSTEM THEORY, H. E. Koenig and W. A. Backwell. McGraw-Hill Book Co., Inc., 330 W. 42 St., New York 36, N. Y., 1961; 504 pages, 6¼ by 9¼ inches, bound; $14.50. An expanded concept of electrical network theory, called linear graph theory, is developed and applied to the analysis of lumped-parameter systems. Specifically, the subjects of rotating machinery, polyphase systems and servomechanisms have been integrated into this discipline along with the aspects of mechanics, hydraulics, and electronic circuits found in control systems. The development presents an orderly operational procedure for deriving mathematically the characteristics of systems of components from a knowledge of the component characteristic and their prescribed mode of interconnection.

PROGRESS IN LOW TEMPERATURE PHYSICS, VOLUME III. Edited by C. J. Gorter. Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y., 1961. 495 pages, 6¼ by 9¼ inches, bound. $15. A variety of topics are surveyed in this volume, which covers vortex lines in liquid helium-2, helium ions in liquid helium-2, liquid and solid helium-3, helium-3 cryostats, superconductivity, electron resonances in metals, orientation of automic nuclei at low temperatures, solid-state masers, the equation of state and the transport properties of the hydrogenic molecules, and solid-gas equilibriums at low temperatures.

REACTOR HANDBOOK, VOLUME II: FUEL REPROCESSING, S. M. Stoller, R. B. Richards (editors). Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y., 1961; 665 pages, 7½ by 10 inches, bound; $21.40. Aspects of fuel reprocessing covered in this volume include aqueous and nonaqueous separation processes, reconversions, radioactive waste disposal, and engineering design, with emphasis on the engineering aspects. In this edition an attempt has been made to reduce the coverage of obsolete processes to a minimum, and to extend the coverage of the first edition to include data on reconversion, isotope separation, plant, and equipment design and cost. Greater emphasis has also been placed on author references and correlating data rather than mere compilation.

RADIOISOTOPE APPLICATIONS ENGINEERING, Jerome Kohl, et al. D. Van Nostrand Co., Inc., 120 Alexander St., Princeton, N. J., 1961; 562 pages, 6¼ by 9¼ inches, bound; $16.50. Basic useful material is first provided on such topics as nuclear physics, shielding, legal and safety aspects, calculations for a tracer experiment, and the measurement of nuclear radiation. Radioisotope applications are then discussed, including the measurement of flow, leakage, and concentration, the determination of friction and wear, radiography, thickness and density gauging, radiation processing, and process engineering applications. A large appendix contains reference material.

PLASTICS IN NUCLEAR ENGINEERING, J. O. Turner. Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y., 1961; 139 pages, 5¼ by 7½ inches, bound; $5.50. In this book practical plastics applications are discussed from the viewpoint of the engineer dealing with nuclear research apparatus. The author describes the uses of plastics in the measurement of radiation, radiation protection, high-voltage service, low-voltage service, magnets, and high-vacuum apparatus. In addition, optical applications and mechanical, thermal, and miscellaneous uses are considered.

AN INTRODUCTION TO THE PRINCIPLES OF COMMUNICATION THEORY, John C. Hancock. McGraw-Hill Book Co., Inc., 330 W. 42 St., New York 36, N. Y., 1961; 253 pages, 6¼ by 9¼ inches, bound; $9.50. The basic concepts of nondeterministic or random time functions and their application to the analysis and synthesis of communication systems are presented. The author discusses frequency and time domain, modulation, random signal theory, network analysis, basic information theory, noise, and communication systems. Recent developments included are probability of error in a discrete phase-modulated system, derivation of the doppler spectrum for an air-to-ground navigation system, and optimum trade-off between signal-to-noise ratio and bandwidth.

MATHEMATICAL MACHINES, VOLUMES 1 & 2, F. J. Murray. Columbia University Press, 2960 Broadway, New York 27, N. Y., 1961; 7½ by 10¼ inches, bound; two volumes; $12.50 and $17.50. The first volume of this set discusses the basic principles of digital computers, stressing fundamental ideas rather than engineering detail. Mathematical devices are considered in order of increasing complexity, and include registers, counters, adding machines, automatic calculators, punched card machines, and automatic sequence calculators. The second volume is concerned with continuous devices, and is divided into three parts dealing with continuous computers, true analogs, and mathematical instruments.

TECHNICAL LITERATURE

For copies of publications listed please write to the addresses given.

INFORMATION THEORY, STATISTICAL DECISION FUNCTIONS, RANDOM PROCESSES. This publication contains papers presented at the Second Prague Conference, held in 1959. Some of the 48 papers include: Continuous Stochastic Approximations, The Entropy of the Swedish Language, An Electronic Generator of Random Sequences, and Fundamental Equations of the Theory of Pursuit. Priced at $22, the 843-page book is available from Academic Press, Inc., 111 Fifth Ave., New York 3, N. Y.

NATIONAL FIRE CODES. A revised 7-volume edition of the National Fire Codes has just been published by the National Fire Protection Association. These 1961-62 codes incorporate 48 fire protection standards adopted by the Association this year, plus 138 other current NFPA standards. Material is divided into seven major categories covering standards on flammable liquids and gases; combustible solids, dusts, chemicals and explosives; building construction and equipment; fixed extinguishing equipment; electrical standards; transportation; and mobile fire equipment, organization, and management. The seven volumes total 5,846 pages, are priced at $7 per volume or $40 for the set, and are available from the Publications Department, NFPA, 60 Batterymarch St., Boston 10, Mass.

PROGRESS IN NUCLEAR ENERGY, SERIES IV; TECHNOLOGY, ENGINEERING AND SAFETY, Vol. 4. This latest volume in a review series titled "Technology, Engineering and Safety," includes reviews under the general headings of engineering, nuclear reactor technology, materials and processes, and nuclear safety. Contributions on the use of helium, a review of graphite technology, and a review on plutonium ceramics are included. Process technology is covered by reviews which include accounts of American developments of the gas-solid and liquid-liquid chemical engineering operations involved in processing and reprocessing uranium fuels. A section deals with the complex criticality considerations of transporting fissile materials, and the last two chapters review the study and design of safe nuclear installations. The 320-page book is priced at $15.00 from Pergamon Press, Inc., 122 E. 55 St., New York 22, N. Y.

HANDBOOK OF ASTRONAUTICAL ENGINEERING, H. H. Koelle (editor). This is a summarization of the present state of the art of space flight technology. Prepared by a team of 150 specialists, with a foreword by Wernher von Braun, the Handbook is the result of three years' work in screening books, articles, and reports for the essential information and data required by the design engineer and scientists to design space vehicles and to calculate their performance and cost. The book is broken down into six parts:

fundamentals of astronautical engineering, astrodynamics, astrionics, propulsion systems, space vehicles, and space flight operations. The 1,814-page book, with 1,052 illustrations, is priced at $27.50, and can be ordered from McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N. Y.

USING THE OSCILLOSCOPE IN INDUSTRIAL ELECTRONICS, R. G. Middleton, L. D. Payne. This book provides specialized information on the use of the oscilloscope in testing and maintaining various industrial electronic devices. It shows how to make accurate tests and measurements with this instrument. The first chapters present a general understanding of industrial scopes — oscilloscope information capability, operating features, characteristics, and an introduction to the use of the oscilloscope in industrial electronics. Specific applications of the scope in testing and maintaining electronic devices are discussed. The last three chapters cover waveform photography, scope applications in the laboratory, and maintenance of oscilloscopes. The book is priced at $4.95, is 256 pages long, and is available from Howard W. Sams & Co., Inc., 1720 E. 38 St., Indianapolis 6, Ind.

INDUSTRIAL INSTRUMENTATION, F. C. Tyson, Jr. This text is based on material used for a technician's course in industrial instrumentation. The emphasis is on broad, general principles; the book includes the necessary physics, mathematics, and mechanical engineering when these are required for the course. Electrical and electronic instrumentation are not dealt with—the volume is concerned with pneumatic control, which comprises more than 80 per cent of instrumentation now in use. The 357-page book is priced at $9.00, and is available from Prentice-Hall, Inc., Englewood Cliffs, N. J.

ELECTRONIC DIGITAL COMPUTERS, G. S. Smirnov. Translated from the Russian, this book gives an account of the mathematical fundamentals of construction of electronic digital computers. The working principles are described, the circuits of the individual components and assemblies are examined, and their characteristics given. The areas covered include classification of the methods of computer technique, mathematical fundamentals, programming, function schematics, components, arithmetic units, storage units, control units, etc. Priced at $4.50, the 150-page book is published by Pergamon Press, Inc., 122 E. 55 St., New York 22, N. Y.

FUNDS FOR RESEARCH AND DEVELOPMENT IN INDUSTRY, 1958. Issued by the National Science Foundation, this report is fourth in the series of Foundation-sponsored surveys of industrial research and development. The survey, conducted by the U. S. Bureau of the Census, provides details on the performance, financing, and other economic characteristics of research and development in virtually the entire industry sector of the economy, including the R & D activities of Federal contract research centers administered by industrial firms. Copies may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., for 65¢.

WATER HAMMER IN HYDRAULICS AND WAVE SURGES IN ELECTRICITY, Louis Bergeron. This reference work is designed to help engineers and others to keep up to date with progress in the field of hydraulics. Its major purpose is to inform hydraulic engineers of the methods of calculating water hammer. The second section is devoted to a number of examples chosen from the hydraulic field. The third section applies to other branches of mechanics, including a discussion of electric lines. The book may be ordered from the American Society of Mechanical Engineers, Order Dept., 345 E. 47 St., New York 17, N. Y., and is priced at $15.

HYDRAULIC RESEARCH IN THE UNITED STATES, Helen K. Middleton (editor). National Bureau of Standards Miscellaneous Publication 238 contains information compiled from hydraulic and hydrologic laboratories in the United States and Canada. Information given includes the number and title of each project, its sponsor, nature, description and present status, results, publications, and name of correspondent (who can furnish further information on the project). The 220-page report is priced at $1.25 from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

INDUSTRIAL TRANSISTOR AND SEMICONDUCTOR HANDBOOK, Robert Tomer. In this book the author has compiled most of the essential information needed to understand the many types of semiconductors which are available. Fundamentals, operating characteristics, circuit-design procedures, and typical applications are discussed, as are the various processes used to manufacture semiconductors. Newer areas of semiconductors covered are thermoelectricity, energy conversion, power inverters and converters, high power audio and modulators, micromodules, high-power radio frequency, thin-film circuits, integrated circuits. Priced at $4.95, this 256-page book is published by Howard W. Sams & Co., Inc., 1720 E. 38 St., Indianapolis 6, Ind.

ELECTRIC UTILITY TERMS. An 84-page "Glossary of Electric Utility Terms" and a 16-page "Nuclear Supplement to the Glossary of Electric Utility Terms" have been published by the Edison Electric Institute. The Glossary contains definitions of about 400 of the principal financial and technical reporting terms relating to the electric utility industry which appear in the statistical publications of the Institute. A 2-page listing of abbreviations of terms most commonly used is given. The Nuclear Supplement is a compilation of definitions of about 80 terms relating to the electric industry's nuclear development program. Both are available from the Edison Electric Institute, 750 Third Ave., New York 17, N. Y., the Glossary for 50¢; the Supplement, 25¢.

HANDBOOK OF ELECTRONIC CHARTS AND NOMOGRAPHS, Allan Lytel. This handbook contains 58 electronic charts and nomographs which will help engineers and technicians derive answers to electronic formulas. The charts and nomographs are positioned one on a page, and on one side only. The back-up side of each preceding page tells how to use each nomograph. A clear vinyl overlay sheet, hinged from the bottom of the back cover, may be positioned over any nomograph. The user can rule in erasable pencil lines to connect the appropriate points on the graph scales. Priced at $4.95, the handbook is available from Howard W. Sams & Co., Inc., 1720 E. 38 St., Indianapolis 6, Ind.

WRITING BETTER TITLES AND ABSTRACTS, John D. Stevens. This bulletin gives suggestions to technical writers for improving titles and abstracts. Organization and brevity are stressed, and examples are used to illustrate the author's points. The 11-page pamphlet, designated Bulletin no. 254, is available free of charge on request from the Technical Extension Service, Washington State University, Pullman, Wash.

NEMA STANDARDS PUBLICATIONS. The following new and revised publications have just been issued. *DH1-1961, Dehumidifiers, 25¢,* establishes a uniform procedure for determining the performance of self-contained electric dehumidifiers, and covers definitions, ratings, tests, and safety. *EW4-1961, Colors for Identification of Arc-Welding Electrodes, 25¢,* contains color chips for covered and cut-length bare arc welding electrodes in EW2 and EW3. *LI3-1961, High-Temperature Properties of Industrial Thermosetting Laminates, 35¢,* shows the results of additional high-temperature work done since 1959 on the flexural and dielectric strength of various grades of laminates. *VF9-1961, Varnished Polyester Non-Woven Fabric, 25¢,* covers ordering, methods of test, dimensions, physical and electrical properties, manufacture, packing, marking, and inspection of yellow and black fabrics used as electrical insulation. *WC5-1961, Thermoplastic-insulated Wire and Cable, $3.50.* This book describes conductors, grades of insulation, protective coverings, and constructional and dimensional details of most thermoplastic-insulated wires and cables in the range of 0 to 15,000 volts, and includes data on specific types. The thermoplastic insulations and jackets covered are compounds made from polyvinyl chloride, or the copolymer of vinyl chloride and vinyl acetate, or polyethylene. *WC30-1961, Color Coding of Wires and Cables, 35¢,* covers asbestos-insulated range wire; flexible cords; and wires and cables insulated with rubber, thermoplastic compounds, asbestos, asbestos-varnished cloth, and asbestos-thermoplastic insulation. *WD-1-1961, American Standard Outlet Receptacles, Attachment Plug Caps and Appliance Plugs, $1.50,* deals with configurations and dimensions of 125-volt, 125/250-volt, 250-volt, and 277-volt, midget-locking-type and locking-type caps and receptacles, and with

appliance plugs and receptacles. Order (minimum order $1) from the National Electrical Manufacturers Assn., 155 E. 44 St., New York 17, N. Y.

OTS REPORTS. The following publications have been made available to the public by the Office of Technical Services. *Optics in Equipment for the Utilization of Solar Energy, V. B. Veinberg. Order AEC-tr-4471, 257 pages, $3.50,* is a translation of a solar energy study by a leading Soviet scientist. It includes a history of solar energy devices, a review of present uses in the U.S.S.R., and predictions for future uses. *USSR Electric Power, Selected Translations. Order 61-31440, 60 pages, $1.75,* is a collection of nine articles on electric power, translated from Soviet technical journals. *Solution to an Explosive Switch Production Problem through the Use of Quality Control, J. R. Craig et al. Order SCTM 67-61-13, 13 pages, 50¢,* reports the solving of a production problem by reverting to the original tooling design. *Energy Conversion Systems Reference Handbook, Electro-Optical Systems, Inc. et al.,* is an 11-volume report series summarizing a 1-year evaluation of power sources and energy converters applicable to space exploration. The individual volumes may be ordered by number at the prices given: *Vol. 1, PB 171 858, General Systems Considerations, 136 pages, $2.75; Vol. 2, PB 171 859, Solar-Thermal Energy Sources, 498 pages, $6.00; Vol. 3, Dynamic Thermal Converters, AD 256 701, 214 pages, $3.50; Vol. 4, Static Thermal Converters, AD 256 702, 210 pages, $3.50; Vol. 5, Direct Solar Conversion, PB 171 862, 207 pages, $3.50; Vol. 6, Chemical Systems, PB 171 863, 202 pages, $3.50; Vol. 7, Heat Exchangers, AD 256 881, 286 pages, $4.00; Vol. 8, Other Devices, AD 256 882, 145 pages, $2.75; Vol. 9, Solar System Design, AD 256 748, 97 pages, $2.25; Vol. 10, Reactor System Design, AD 256 884, 125 pages, $2.75; Vol. 11, Radioisotope System Design, PB 171 868, 316 pages, $5.00.* The entire set is priced at $39.50. *Symbolic Address-Symbolic Optimum Programs for a Drum-Memory Computer, J. K. Russell. Order PB 151 999, 42 pages, $1.25,* is an evaluation of a time-saving, optimized data program couched in simple, symbolic language "understood" by a memory drum computer. *Solid-State Logical Transducers, F. E. Battocletti et al. Order PB 161 668, 39 pages, $1.00,* is an Air Force report investigating semiconductor switching phenomena that might be used in constructing components to execute complex logical operations. *Nuclear Fuels and Materials Development, Division of Reactor Development, AEC. Order TID 11295, 171 pages, $2.75,* is a progress report on nuclear fuels and reactor materials development. *Controlled Thermonuclear Reactions—A Selective Bibliography, S. F. Lanier et al. Order TID-3072 (Rev. 1), 185 pages, $2.75,* contains 1,395 annotated references on research reports and journal articles relating to thermonuclear research. *Direct Energy Conversion Devices — A Literature Search, H. D. Raleigh. Order TID-3561, 23 pages, 50¢,* consists of 208 unclassified references on nuclear direct energy conversion devices. *Reactor Safety—A Literature Search. Order TID-3525 (Rev. 3),* lists 741 references to research and development reports on reactor safety. Order from OTS, Washington 25, D.C.

RUSSIAN TRANSLATIONS

GENERAL INFORMATION

The publication of the translated Tables of Contents and reviews of articles from the translated issues of *Radio Engineering, Radio Engineering and Electronic Physics,* and *Telecommunications* is continued in this issue of *Electrical Engineering.* The translated issues of the three Russian journals are published by the AIEE with the co-operation of Royer and Roger, Inc. Normal publication of translations will take place 18 weeks after the appearance of the original text.

Page 36A of the September issue of *Electrical Engineering* gives a full description of subscription rates and special reduced rates for individual subscribers as well as a tear-out return postcard. Further information and subscriptions may be obtained from: AIEE, Special Subscription Department, 41 East 28th Street, New York 16, N. Y.

TRANSLATED TABLE OF CONTENTS

RADIO ENGINEERING, Vol. 16, No. 7, July, 1961

1. *Neiman, M. S.,* Construction Principles for Memory Elements and Code Selection in High-Frequency Intermittent Control Systems
2. *Baikovskii, B. M.,* Carrying Capacity of a Channel with Discrete Difference Modulation
3. *Oavlov, Yu. V.,* Method for Determining Loss in Antennas
4. *Orlov, S. I.,* Synthesis of Smooth Transitions
5. *Kriksunov, V. G.,* Possible Method for Generating HF Sine Waves
6. *Tomashpol'skii, A. M.,* Application of Cathode Repeaters to Phantastron Circuits
7. *Saprykin, K. V.,* Conditions for Obtaining Images of Equal Definition with Line and Spiral Scanning
8. *Model', A. Z., Dranginis, V. V.,* Highly Stable Output Stage for Transistorized Low-Frequency Sweep Oscillators
9. *Gofman, B. A., Yablonskii, F. M.,* Application of Thyratron Glow Lamps to Motor Control with Gas-Discharge Counters and Commutator Tubes
10. *Bamberskii, M. V., Shelukhina, T. V.,* Thermal Calculations for Ferrite Resonance Valves
11. *Abramson, Yu. M.,* Author's Report and Selection of Waveguide Filters for Shielded Housings
12. *Siforov, V. I.,* Project for Consistent Terminology in Radio-Electronic Reliability Theory
13. In the A. S. Popov NTORE (Scientific Technical Society of Radio Engineering and Communication)

RADIO ENGINEERING AND ELECTRONIC PHYSICS, Vol. 6, No. 7, July, 1961

1. *Basharinov, A. Ye.,* Problems in the Statistics of Automatic Recognition of Patterns in Multiframe Observation
2. *Fleyshman, B. S.,* Nonstationary Regime of Filling the Memory of a Cybernetic Device for Statistical Recognition of Patterns
3. *Zyatitskiy, V. A.,* An Analogue of the Filling of the Memory of a Cybernetic Device from the Method of Self-Analysis
4. *Nesteruk, V. F.,* The Theory of the Optimal Detection of a Compound Signal with Correlated Noise
5. *Stratonovich, R. L.,* Optimal Reception of a Narrow-Band Signal at an Unknown Frequency on a Background of Noise
6. *Dorman, M. I.,* Spectrum of an Oscillation Whose Frequency Passes Through Zero
7. *Tikhonov, V. I.,* The Markov Nature of the Envelope of Quasiharmonic Oscillations
8. *Rizkin, I. Kh.,* The Characteristics of Nonlinear Elements of Frequency Dividers
9. *Ivanchikov, V. I.,* Some Problems in the Theory of Refraction of Electromagnetic Waves
10. *Pavlov, P. P.,* The Electromagnetic Field and the Current Distribution Along an Infinitely Long Uninsulated Wire in a Conducting Medium
11. *Kokhlov, R. V.,* The Propagation of Waves in Dispersing Nonlinear Lines
12. *Benenson, L. S.,* Computation of the Phase Velocity of Waves in an Artificial Metal Dielectric with the Current Harmonics in the Elements of the Structure Taken into Account
13. *Shestopalov, V. P., et al.,* Theoretical and Experimental Studies of Helical Dielectric Antennas
14. *Bakhrakh, L. D., Vavilova, I. V.,* Spherical Two-Mirror Antennas
15. *Matveyev, R. F.,* Computation of the Side Flow in a Long Waveguide Line
16. *Gurevich, S. B.,* The Sensitivity of TV Systems with Different Scanning Parameters
17. *Petrov, Ye. N.,* The Theory of a Flat-Plate Triode with a Zero Space Charge in the Gap Between the Grid and the Anode
18. *Braginskiy, V. B., et al.,* Study of the Operation of a Frequency Multiplier Containing a Nonlinear Capacitance from a P-N Junction
19. *Mikhaylovskiy, L. K., et al.,* Nonlinear Gyromagnetic Effects of the Nutation Type in Ferrites
20. *Mikaelyan, A. L.,* Coupling Phenomena Between a Resonator and Ferrite
21. *Rodak, M. I.,* Computation of the Polarizations of an Alternating Magnetic Field Which Corresponds to the Extreme Transition Probabilities in Paramagnetic Resonance
22. *Van Khyan'-chzho,* Computation of a Matching Metal Insert for a Waveguide of Circular Cross Section
23. *Fedotov, A. P., et al.,* The Requirements for

Stability of the Amplitude and Phase in the Cavity Resonators of Linear Accelerators
24. *Fetina, V. N.*, The Excitation of Even Harmonics in Ferroresonance
25. *Nakhodkin, N. G., et al.*, The Photoeffect in the Region of Soft X-Rays
26. *Petrov, I. M., et al.*, Regarding the article of Kuklev, L. P., and Ozerskiy, Yu. P., entitled, "A Comparison of Two Methods of Decoding Interval Codes."
27. *Kuklev, L. I., et al.*, Answer to the letter of Petrov, I. M., and Tyslyatskiy, G. S.
28. *Khlebnikov, N. S., et al.*, The Problem of the Influence of the Polarization of Light on the Photoeffect in Complex Cathodes

TELECOMMUNICATIONS, Vol. 15, No. 6, June, 1961

1. *Andronov, I. S.*, Potential Noise Immunity and Conditions for Realization of Separate Signal Reception Method in Frequency Telegraphy
2. *Levin, B. R., Rozanov, V. S.*, Calculation of the Number of Multichannel Systems with Interval Pulse-Time Modulation
3. *Korobov, Yu. F.*, Some Synchronization Systems for Synchronous Direct Amplification Receivers
4. *Pokras, A. M., Kinber, B. E.*, Radiation Pattern of a Periscopic System with Ellipsoidal Radiator
5. *Aleksandrov, N. V., Gershenzon, E. M., Etkin, V. S.*, Regenerative Low-Noise Super-High Frequency Amplifiers
6. *Liushite, I. A., Herziger, L. N.*, Frequency-Keyed Resistance-Capacitance Oscillator
7. *Nagornyy, L. Ya*, Variations of Network Parameters Versus Variations of One of Its Elements
8. *Grigor'ev, G. L.*, Traffic Capacity of a Group of Devices Serviced by Two Master Systems
9. *Drobyshev, Yu. P.*, On the Density of Magnetic Recording
10. *Lakernik, R. M., Sharle, D. L., Schwarzman, V. O.*, Review of Basic Trends in the Development of Cable Technology in City and Intercity

REVIEW OF TRANSLATED ARTICLES

The following reviews cover articles in the first two 1961 issues of Telecommunications

Telecommunications Vol. 15, No. 1 January 1961

Application of Varistors to Arc Quenching. *Raukas, E. E.*

This article, which defines a varistor as a nonlinear semiconductor resistance whose value depends on the applied voltage, presents empirical formulas for approximating the volt-ampere characteristics of the low-power silicon-carbide varistors produced by the Russian industry. The circuit used for studying the volt-ampere characteristics is shown and a typical volt-ampere curve is illustrated.

A nomogram for determining suitable parameters for an arc-quenching varistor is presented. The nomogram can be used for the case of a varistor to be connected across the inductance load of the circuit to be interrupted or across the contacts which interrupt the circuit. Formulas for calculating the power dissipated by an arc quenching varistor are also developed.—F. W. Smith

High-Frequency Telephone Communication with Semiconductor Triodes. *Egorov, K. P., Sukhodoev, I. V.*

The objective is to improve intraregional telephone communications over a single pair cable presently limited in distance and to one channel of low quality.

The development of a 3-channel system is described. It comprises a single-channel plus a 2-channel group. In one direction the single channel occupies the spectrum from 0.3 to 6.1 kc and the 2-channel group from 8.3 to 15.7 kc. In the other direction the corresponding frequencies are from 0.3 to 2.7 kc and from 18.9 to 26.3 kc. Emphasis is placed upon miniaturization and the design of the oscillators and the amplifiers. Correction of frequency and nonlinear distortion, and optimizing the signal-to-noise ratio are also covered.—A. E. Frost

Low Frequency Regenerative Divider. *Andreev, V. S., Burdzeiko, B. P., Vasil'ev, V. I.*

A divider of the regenerative type where the usual tuned circuits have been replaced by RC null-T frequency selective amplifiers is described. This type of circuit is especially useful at frequencies of less than 10 cycles because of the high Q which is independent of the output frequency. A trapezoidal waveform at the output frequency is differentiated to produce both positive and negative pulses which ring a frequency multiplier. By adjusting the circuit parameters for symmetrically timed pulses, the divisions are limited to even ratios. For uneven division ratios, the circuit is adjusted for an unsymmetrical waveform. The performance of certain test dividers with division ratios between 5 and 20 are described. Some of the settings are critical for optimum performance, and it is necessary to carefully select the parameters for the null-T networks. Good stability against variations of the signal input voltage and variations in the B supply voltage are claimed.

The output waveform is very good for a low-frequency divider. No comments are made about jitter problems at low frequencies so it can be assumed they are negligible with this system using RC filters. Sufficient information is given to enable one to breadboard and line up a circuit.—A. G. Cooley

Telecommunications Vol. 15, No. 2 February 1961

Miniature Delay Line with High Resolution. *Solov'yev, V. A.*

This paper discusses the design and properties of spiral-wound delay lines with distributed parameters. The line consists of wire wrapped in a spiral about a small core in a manner similar to other distributed constant delay lines. The unique feature of this line is that it is electrically sectioned by short-circuited coils uniformly spaced along the line. The parameters of each section are determined from the m-derived equivalent low-pass structure. The necessary isolation between such equivalent section is provided by this action of the short-circuited coils.

Complete design equations are given. The parameters are determined from the required rise-time, the characteristic impedance, and the isolation required between sections.

It is claimed that delay lines can be built for characteristic impedances in the range 1.5 to 9.3 kilohms, with rise times of 20 nanoseconds, and delays of the order of 30 to 100 nanoseconds in a volume of less than 1 cm^3.—W. A. Miller

System for Control of Radiation Pattern of Complex Wideband Antenna with Low Side-Lobe Level. *Kuznetsov, V. D., Paramonov, V. K.*

This paper describes a method of steering the horizontal radiation pattern of a colinear array of radiators. Steering is accomplished by properly varying the phases of the currents in the various elements of the array. Minimum side-lobe level is attained by adjusting the magnitudes of the currents in the array elements to fit the Dolph-Chebyshev distribution.

Phase-shifting is accomplished by using tapped artificial lines—one line for each pair of radiators. Amplitude matching is accomplished by using attenuators.

A colinear, eight-element receiving array was tested in the 30-60 mc range and the horizontal pattern was found to be steerable through an angle of 30 degrees without appreciable increase in the amplitudes of the side-lobes.

The main discussion dealt with reception. There was some discussion of steerable transmitting arrays, and more details concerning the latter are promised in a sequel.—W. A. Miller

Passage of FM Oscillations Through Aperiodic Amplifier. *Rychka, V. L.*

The transmission of FM oscillations through an aperiodic amplifier are on modulating frequencies of 15 kc, maximum deviation of 50 kc and intermediate frequencies of 200 kc.

The analysis shows that for the general case of multistage aperiodic amplifiers the distortions can be ignored. If precise measurements of the frequency response of a transmitter are required, there is need to consider frequency-amplitude distortions of the FM signal in the amplifier. Both linear and nonlinear phase distortions are considered.

When the signal is pulse modulated, it is assumed the frequency at the input to the amplifier switches instantly from center frequency to maximum deviation frequency and that the switching can take place at any random phase relationship between the two frequencies. Since this is not true in the usual modulation systems there is even less reason for concern than indicated by the author.—A. G. Cooley

AIEE ON THE MOVE

UET Opens Cornerstone Box from Old Engineering Societies Building

The cornerstone box from the recently closed Engineering Societies Building on West 39th Street was opened at a luncheon of the UET (United Engineering Trustees, Inc.) Board of Trustees, held at the new United Engineering Center, September 28, 1961. Guests representing the Carnegie Endowment for International Peace, the United Nations, presidents and secretaries of the Founder Societies, associate societies, and other joint agencies were present. The new United Engineering Center is occupied by 19 professional engineering organizations, including the Five "Founder Societies."

The cornerstone of the old building was laid May 8, 1906, in impressive ceremonies with Andrew Carnegie and family participating. On opening the box, a gold plate of Mr. Carnegie's original presentation letter dated March 14, 1904, was found in which he announced, "It will give me great pleasure to devote, say $1.5 million for the erection of a suitable home for you all in New York." It was this gift that made the original Engineering Societies Building possible. Among other items found in the box were the Charter and Bylaws of the United Engineering Trustees, membership records at that time of the ASME, AIME and AIEE, plans of the building, magazines and newspapers, and a proof set of United States coins of 1906.

The new United Engineering Center, located at 345 East 47th Street, New York, N. Y., includes the Engineering Societies Library, which is one of the largest free public engineering libraries in the world with an eventual capacity of one-quarter million volumes. The Library came into being as a result of Mr. Carnegie's original gift, and it is maintained by UET.

Among the luncheon guests were J. E. Johnson, president, Carnegie Endowment for International Peace; Roberto Tehurtematte, Under Secretary of the United Nations and United Nations Commissioner for Technical Assistance; Daniel Kennedy, Public Affairs Officer, United States Mission to the United Nations; Joseph Gilbert, general manager, Society of Automotive Engineers; J. M. Gleason, national director, Boys' Club of America, and Miss Frances Selig of the ASME staff whose services over the period of a half century spans the dedication of both buildings. W. F. Thompson, president of UET, presided.

Wagner-International

Members of UET who examined gold plate of Andrew Carnegie's gift letter are (left to right): *F. S. Blackall, Jr.; J. H. R. Arms, former secretary (retired), and AIEE representatives—J. F. Fairman; L. F. Hickernell; W. J. Barrett, UET past-president; W. F. Thompson, UET president; Andrew Fletcher, UET past-president, and S. W. Marras, UET secretary and general manager*

Technical Sessions and Exposition To Be United at Winter General Meeting

A full-scale 5-day technical program that will blanket the entire electrical-electronics field is in the making for the Winter General Meeting of AIEE and the 1962 Electrical Engineering Exposition in New York City.

More than 800 research engineers in every segment of the electrical-electronics industry have been invited to present technical papers at some 120 separate sessions that will be held January 29-February 2, 1962.

N. S. Hibshman, Executive Secretary of AIEE, said that at least 35 per cent of the technical sessions will be held in meeting rooms in the New York Coliseum, scene of the AIEE-sponsored Electrical Engineering Exposition.

This will make it possible for those attending the conference sessions to move more easily into the exhibit areas where they will see actual demonstrations of the principles, procedures and materials they had heard discussed, Mr. Hibshman explained. This is a part of the Institute's deliberate effort to integrate the technical and scientific sessions with the Exposition.

Mr. Hibshman said that the Electrical Engineering Exposition "is by no means the trade show or product supermarket that has become the common stand-by in some other industries."

The Exposition is planned as an entirely new approach to the concept of the trade show. More than just a show of products and services offered by the nation's leading suppliers, it is to be a teaching exposition specifically designed to augment the AIEE technical sessions. The exhibits at the Exposition will be based upon the research efforts of electrical-electronics engineers from throughout the country. They are intended to provide AIEE engineers with first-hand visual evidence of the advancing technology of the electrical-electronics industry and help keep them abreast of the great range and swift pace of developments in electrical engineering.

H. F. Grebe, exhibits manager of the Reber-Friel Company of Philadelphia, Pa., exposition management firm in charge of the Exposition, said a review of the exhibits shows that this will not be "a one-subject affair." Exhibits will represent every segment of the electrical-electronics industry, Mr. Grebe said, and will be a haven for the cross-breeding of ideas. He said that 40 percent of the exhibit space has already been reserved and that space assignments are now being made.

Detailed information about the Electrical Engineering Exposition may be obtained from the Reber-Friel Company, 117 S. 17th St., Philadelphia 3, Pa.

Exhibit space has been assigned the following companies:

Alford Manufacturing, Allis-Chalmers, Automatic Electric Sales, Automatic Switch, Borg-Warner Corporation, James G. Biddle, Buchanan Electrical Products, Burndy Corporation, Ceramaseal, Inc., Circle F Manufacturing, Clark Controller, Cleworth Publishing, Collyer Insulated Wire, Copperweld Steel, Crucible Steel Company of America, Curtis De-

velopment and Manufacturing, Cutler-Hammer, Inc., A. B. Dick, Dossert Manufacturing, Dukane Corporation, Eaton Manufacturing, Electromode Division of Commercial Controls, Electro Switch Corporation, Encyclopaedia Britannica, Esterline Angus Instrument, Furnas Electric, General Electric, Hendrix Wire and Cable Corporation, Hoffman Engineering Corporation, Harvey Hubbell, Inc., Hughes Electronics, Jerome Hydraulics, Kaiser Aluminum & Chemical, Kay Electric, Kearfott Division of General Precision, Kewaunee Scientific Equipment, Kulicke & Soffa Manufacturing, Lundell & Co., Magnetics, Inc., Magnetic Metals, Motor Coil Manufacturing, Molecular Dielectrics, National Electrical Coil Division of McGraw-Edison, Okonite, P-W Industries, Inc., Permali, Reliable Electric, Reynolds Metals, Rome Cable Division of Alcoa, Rockbestos Wire & Cable, Rohde & Schwarz Sales, Inc., Rowan Controller, S & C Electric, Simplex Wire & Cable, Simpson Electric, Stahlin Brothers, Inc., Standard Transformer, Superior Electric, Thomas & Betts, Inc.. Warner Electric Brake & Clutch, Wilmad Glass, Inc., Yokogawa Electric Works, and Zero-Max.

Fortescue Fellowship Award Made Available to Applicants for 1962-63

Funds have been made available for one or more Charles LeGeyt Fortescue Fellowships for 1962-63. The amount of the award has been fixed at $2,500. The awards are made to postgraduate students in the field of electrical engineering who have received their baccalaureate degree from a duly recognized technical school in the United States or Canada.

Candidates for the Charles LeGeyt Fortescue Fellowships should file applications on the form provided by AIEE so that they may reach the Chairman of the Fellowship Committee by January 15, 1962. Awards will be made not later than March 1, 1962. Copies of the application forms are available at accredited colleges or by writing to Mrs. A. L. Landres, Secretary of the Professional Development and Recognition Department, American Institute of Electrical Engineers, 325 E. 47 St., New York 17, N. Y.

The Charles LeGeyt Fortescue Fellowship, sponsored by AIEE, was established in 1939 as a memorial to Charles Fortescue in recognition of his valuable contribution to the electric power industry. To this end, the Westinghouse Electric Corporation, with which Dr. Fortescue was associated throughout his professional career, set up a trust fund of $25,000 to provide graduate fellowships in electrical engineering. The successful candidates are selected by the AIEE committee which administers the fund.

It is intended that candidates shall pursue their studies at accredited engineering schools and engage in research problems meeting the approval of the Fellowship Committee. To be eligible, the student must have received a bachelor's degree from an accredited college by the time his work under the fellowship is to begin, provided he does not hold or subsequently receive any other fellowship which carries a stipend greater than the tuition required by the institution selected for graduate work.

Institute Technical Groups Are Now in Process of Formation

Institute Technical Groups (ITGs) now in the process of formation include the following:

ITG on Automatic Control, sponsored by Feedback Control Systems Committee, with support of Industrial Control Committee, Industry Division. Contemplated dues $4.00 annually. Applications may be mailed to I. S. Coggeshall, Manager Technical Operations Services, AIEE, 345 E. 47 St., New York 17, N. Y. On August 27, 1961, 217 applications had been received toward an immediate goal of 300.

ITG on Computing Devices, sponsored by Computing Devices Committee, Science and Electronics Division. Contemplated dues $4.00 annually. Address applications to Dr. Lindon E. Saline, General Electric Company, 1811 Lemoin Ave., Syracuse, N. Y.; state whether you would expect the ITG to provide special meetings, special publications, or other services you may wish to name.

ITG on Aero-Space Instrumentation, being formed by Aero-Space Instrumentation Committee, Instrumentation Division. Contemplated dues approximately $4.00 per year. Address applications to I. S. Coggeshall, AIEE, 345 E 47 St., New York 17, N. Y. Application should state opinion as to whether ITG should be limited to Aero-Space Instrumentation activity, or whether it should include Aero-Space Transportation and/or Space Communication activities.

ITG on Aero-Space, being formed by Aero-Space Transportation Committee, General Applications Division. Contemplated dues $4.00 annually. Address applications to I. S. Coggeshall, AIEE, 345 E. 47 St., New York 17, N. Y. Application should state whether ITG should be limited to Aero-Space Transportation activity, or whether it should include Aero-Space Instrumentation and/or Space Communication activities.

Sections should publicize the ITG effort, and invite AIEE members to apply for membership in the ITGs of their choice.

Members may use the coupon accompanying these paragraphs to indicate their interest in other ITGs.

Please add my name to the list of prospective members for the Institute Technical Groups checked below. I understand that I will be billed $4.00 for each group checked as soon as the number of petitioning members reaches 300 for that group.

Communication Division
- ☐ DATA COMMUNICATION
- ☐ TELEGRAPH SYSTEMS

General Applications Division
- ☐ DOMESTIC & COMMERCIAL APPLICATIONS

Industry Division
- ☐ FEEDBACK CONTROL SYSTEMS
- ☐ INDUSTRIAL CONTROL

Instrumentation Division
- ☐ AERO-SPACE INSTRUMENTATION

Power Division
- ☐ POWER GENERATION
- ☐ SYSTEM ENGINEERING
- ☐ TRANSMISSION & DISTRIBUTION

Science & Electronics Division
- ☐ BASIC SCIENCES
- ☐ COMPUTING DEVICES
- ☐ ELECTRONICS

(Send no money) **Signed** _____

(Please print) **Address** _____

_____

RETURN TO:
AIEE Headquarters
Care of ITG CO-ORDINATION COMMITTEE
345 East 47th Street
New York 17, New York

2.

Call for Nominations!

The Recognition Committee of the AIEE is seeking nominees for five AIEE awards, in the fields of:

ELECTRICAL ENGINEERING EDUCATION
TRANSMISSION AND DISTRIBUTION
TELECOMMUNICATION
ELECTRICAL MEASUREMENT
ELECTRONICS

These awards are usually presented at the AIEE Fall General Meeting.

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All members of the Institute are eligible to submit nominees. Such nominations are to be made on a form which may be procured from Mrs. A. L. Landres, Secretary of the Recognition Awards Committee, at AIEE Headquarters, 345 East 47th Street, New York 17, N. Y. Each form should be accompanied by supporting letters from others who are familiar with the accomplishments and qualifications of the nominee. These forms and letters are due at AIEE Headquarters not later than April 1, 1962.

THE MEDAL IN ELECTRICAL ENGINEERING EDUCATION provided for by the Members-for-Life Fund Committee will be given to a teacher of electrical engineering selected for his excellence in teaching and his ability to inspire students to higher achievements; for his contributions to the teaching of electrical engineering through text books and by writings on engineering education; for his active participation in the work of the professional and educational societies; and for his contributions to teaching and the profession through research, engineering achievements, and technical papers.

The award consists of a cash stipend of $500, a bronze medal, and an engraved certificate.

Awards of the medal have been as follows:

1956—F. E. Terman
1957—W. L. Everitt
1958—J. F. Calvert
1959—G. S. Brown
1960—Ernst Weber
1961—G. F. Corcoran

THE WILLIAM MARTIN HABIRSHAW AWARD established by the Phelps Dodge Foundation will be made annually to an individual or group of individuals who have made an outstanding contribution to the field of Electrical Transmission and Distribution.

Mr. Habirshaw was a chemist who pioneered in the first a-c high-voltage cables used in America. He designed the 11,000-volt underground cable system of the Cataract Power & Conduit Company which was installed at Buffalo, N. Y., in 1898 and 1899, and gave very satisfactory service for many years. Mr. Habirshaw was one of the founders of the American Chemical Society.

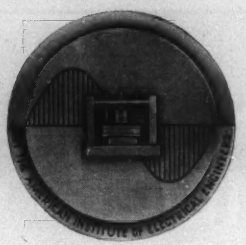
The award consists of a cash stipend of $500, a bronze medal, and an engraved certificate. In the event that the recipient is a group of individuals, the stipend shall be equally divided among the members of the group and a medal and a certificate provided for each.

Awards have been made as follows:

1959—W. A. Del Mar
1960—S. B. Crary
1961—S. B. Griscom

★

Nominations for the awards previously submitted may be brought to the attention of the committee this year by a letter of renomination, plus any additional material bringing the candidate's achievements up to date.

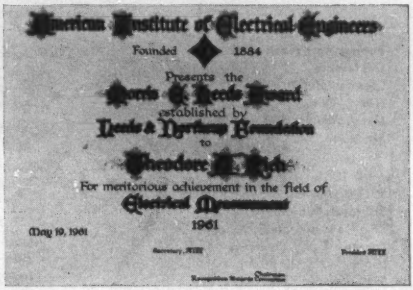


THE MERVIN J. KELLY AWARD established by the Bell Telephone Laboratories, Inc., will be presented annually in the field of Telecommunication.

The award consists of a cash stipend of $1,000, a bronze medal, and an engraved certificate. In the event that the recipient is a group of individuals, a separate award may be made to each of them in a single year provided that the Institute shall withhold making the award for a number of immediately ensuing years equal to the awards in excess of one so made in a single year.

Awards of the medal have been made as follows:
1960—Mervin J. Kelly
1961—H. Nyquist

Morris E. Leeds



THE MORRIS E. LEEDS AWARD established by the Leeds & Northrup Foundation will be presented annually to an individual or group of individuals who have benefited the arts and sciences by making an outstanding contribution to the field of Electrical Measurement, with special consideration given to the value of contributions made before the candidate has reached his 36th birthday.

The award consists of $500 and an engraved certificate. In the event that the recipient is a group of individuals, the stipend shall be equally divided among the members of the group and a certificate provided for each.

Awards have been made as follows:
1959—H. B. Brooks
1960—P. A. Borden
1961—T. A. Rich

THE DAVID SARNOFF AWARD established by the Radio Corporation of America will be given annually in the field of Electronics.

The award consists of a 14-carat gold medal, a bronze replica, and an engraved certificate. Preference is given to achievement by a single individual, but if in the opinion of the Institute's Committee the award should be conferred upon a group of individuals who have functioned as a team, the award may be conferred upon such individuals up to three in number. Each member of such a team will receive a gold medal, a bronze replica, and a certificate.

Awards have been made as follows:
1959—David Sarnoff
1960—Rudolf Kompfner
1961—Charles H. Townes

Future Meetings of Other Societies

Atomic Industrial Forum Annual Meeting, Nov. 6-8, Conrad Hilton Hotel, Chicago, Ill. C. Robbins, Exec. Manager, Atomic Industrial Forum, Inc., 850 Third Ave., New York 22, N. Y.

7th Conference on Radio Interference Reduction and Electronic Compatibility, Nov. 7-9, Illinois Institute of Technology, Chicago 16, Ill. W. McGee, Conference Secretary, Armour Research Foundation, 10 W. 35 St., Chicago 16, Ill.

Operations Research Society of America and Institute of Management Sciences, Joint National Meeting, Nov. 8-10, Jack Tar Hotel, San Francisco, Calif. P. H. Butterfield, Sr. Operations Analyst, Stanford Research Institute, Menlo Park, Calif.

ARI, Annual Meeting, Nov. 12-15, The Homestead, Hot Springs, Va. Air-Conditioning and Refrigeration Institute, 1347 Connecticut Ave., N. W., Washington 6, D. C.

INSTITUTE OF RADIO ENGINEERS
Conference on Magnetism and Magnetic Materials, Nov. 13-16, Hotel Westward Ho, Phoenix, Ariz.

Electronic Systems Reliability Symposium, Nov. 14, Linda Hall, Library Auditorium, 5109 Cherry St., Kansas City, Mo.

Northeast Electronics Research and Engineering Meeting, Nov. 14-16, Commonwealth Armory and Somerset Hotel, Boston, Mass.

NEMA, Annual Meeting, Nov. 13-17, Traymore Hotel, Atlantic City, N. J. R. Gingles, National Electrical Manufacturers Association, 155 E. 44 St., New York 17, N. Y.

SPE, Regional Technical Conference, Nov. 15, Statler Hilton Hotel, New York, N. Y. R. D. Forger, Society of Plastics Engineers, Inc., 65 Prospect St., Stamford, Conn.

Society of Naval Architects and Marine Engineers, 69th Annual Meeting, Nov. 15-17, Waldorf-Astoria Hotel, New York, N. Y. SNAME, 74 Trinity Place, Room 500, New York 6, N. Y.

ASME, Winter Annual Meeting, Nov. 27-30, New York, N. Y. American Society of Mechanical Engineers, 345 E. 47 St., New York 17, N. Y.

NFPA, Technical Committee Meetings, Nov. 27-29, Hotel Manhattan, New York, N. Y. National Fire Protection Assn., 60 Batterymarch St., Boston 10, Mass.

28th Exposition of Chemical Industries, Nov. 27–Dec. 1, Coliseum, New York, N. Y. Publicity Dept., ECI, 480 Lexington Ave., New York 17, N. Y.

OVERSEAS
World Meteorological Organization, Commission for Instruments and Methods of Observation, 3rd Session, Nov.–Dec., New Delhi, India. World Meterological Org., Campagne Rigot, 1, av. de la Paix, Geneva, Switzerland.

International Atomic Energy Agency, Symposium on Radiation Damage in Solids and Reactor Materials, Nov. 27–Dec. 1, location undecided. IAEA, 11 Kärntner Ring, Vienna I, Austria.

Calendar of AIEE Future Meetings

TP—Transactions Paper
CP Syn.—Conference Paper Synopsis
CPMs—Conference Paper Manuscript
DPMs—District Paper Manuscript*

Notice to Authors Strict compliance with the "Author's Guide" will save you time, delays, and unnecessary correspondence. For a copy, write to E. C. Day, 345 East 47 Street, New York 17, N. Y.

November 6, 1961
Western Appliance Conference†
Biltmore Hotel
Los Angeles, Calif.

November 6-8, 1961
AIEE-IRE
Nonlinear Magnetics Conference†
Statler Hilton Hotel
Los Angeles, Calif.

November 12-16, 1961
AIEE-AIP Magnetism and Magnetic Materials Conference†
Westward Ho Hotel
Phoenix, Ariz.

December 10-14, 1961
AIEE-IRE-ACM
Eastern Joint Computer Conference†
Sheraton-Park Hotel
Washington, D. C.

January 9-11, 1962
AIEE-IRE-ASQC-EIA
National Symposium on Reliability Control
Statler Hilton Hotel
Washington, D. C.
(Final date for TP—closed, CP Syn.—closed, CPMs—Nov. 6.)

January 28-February 2, 1962
Winter General Meeting
Hotel Statler Hilton
New York, N. Y.
(Final date for TP—closed, CP Syn.—Nov. 9, CPMs—Nov. 24.)

February 15-16, 1962
AIEE-IRE-U of Pa. International Solid-State Circuits Conference
University of Pennsylvania and Sheraton Hotel
Philadelphia, Pa.
(Final date for TP—Nov. 17, CP Syn.—Dec. 8, CPMs—Dec. 19.)

February 19-22, 1962
AIEE-NEMA
Electrical Insulation Conference
Shoreham Hotel
Washington, D. C.
(Final date for TP—Nov. 21, CP Syn.—Dec. 6, CPMs—Dec. 15.)

March 1-2, 1962
AIEE-IRE-AEC-NBS
8th Scintillation and Semi-Counter Conference
Shoreham Hotel
Washington, D. C.
(Final date for TP—Dec. 1, CP Syn.—Dec. 15, CPMs—Dec. 26.)

March 14-16, 1962
EHV Communication, Control, and Relaying Conference
Baker Hotel
Dallas, Tex.
(Final date for TP—Dec. 14, CP Syn.—Dec. 29, CPMs—Jan. 8)

April 3-5, 1962
Cement Industry Conference
St. Louis, Mo.
(Final date for TP—Jan. 3, CP Syn.—Jan. 18, CPMs—Jan. 29.)

April 4-6, 1962
South Central District Meeting
Hotel Peabody
Memphis, Tenn.
(Final date for TP—Jan. 4, DPMs—Jan. 29.)

April 9-10, 1962
Rubber and Plastic Industries Conference
Sheraton Hotel
Akron, Ohio
(Final date for TP—Jan. 9, CP Syn.—Jan. 24, CPMs—Feb. 2.)

April 10-11, 1962
AIEE-ASME-EIC
Railroad Conference
King Edward Hotel
Toronto, Ont., Canada
(Final date for TP—Jan. 10, CP Syn.—Jan. 25, CPMs—Feb. 5.)

April 17-19, 1962
Rural Electrification Conference
Fort Shelby Hotel
Detroit, Mich.
(Final date for TP—Jan. 24, CP Syn.—Feb. 1, CPMs—Feb. 12.)

April 18-20, 1962
Great Lakes District Meeting
Hotel Van Orman
Fort Wayne, Ind.
(Final date for TP—Jan. 18, DPMs—Feb. 9.)

April 30-May 2, 1962
Mid-America District Meeting
Hotel Chase
St. Louis, Mo.
(Final date for TP—Jan. 30, DPMs—Feb. 23.)

May 1-3, 1962
WJCC Spring Joint Computer Conference
Fairmont Hotel
San Francisco, Calif.
(Final date for TP—Jan. 31, CP Syn.—Feb. 15, CPMs—Feb. 26.)

May 7-9, 1962
Middle Eastern District Meeting
Hotel DuPont
Wilmington, Del.
(Final date for TP—Feb. 6, DPMs—Mar. 2.)

May 8-10, 1962
Joint Electronic Components Conference
Mariott Motel
Washington, D. C.
(Final date for TP—Feb. 7, CP Syn.—Feb. 22, CPMs—Mar. 5.)

May 9-11, 1962
North Eastern District Meeting
Hotel Statler Hilton
Boston, Mass.
(Final date for TP—Feb. 8, DPMs—Mar. 5.)

May 14-16, 1962
Joint District Meeting
Erie, Pa.
(Final date for TP—Feb. 13, DPMs—Mar. 9.)

May 22-23, 1962
Appliance Technical Conference
Deshler-Hilton Hotel
Columbus, Ohio
(Final date for TP—Feb. 22, CP Syn.—Mar. 9, CPMs—Mar. 19.)

May 23-25, 1962
AIEE-ISA-ARS-IAS
National Telemetering Conference
Sheraton-Park Hotel
Washington, D. C.
(Final date for TP—Feb. 22, CP Syn.—Mar. 9, CPMs—Mar. 19.)

June 4-7, 1962
EJC Nuclear Congress
New York Coliseum
New York, N. Y.

June 17-22, 1962
Summer General Meeting
Hotel Denver Hilton
Denver, Colo.
(Final date for TP—Mar. 19, CPMs—April 11.)

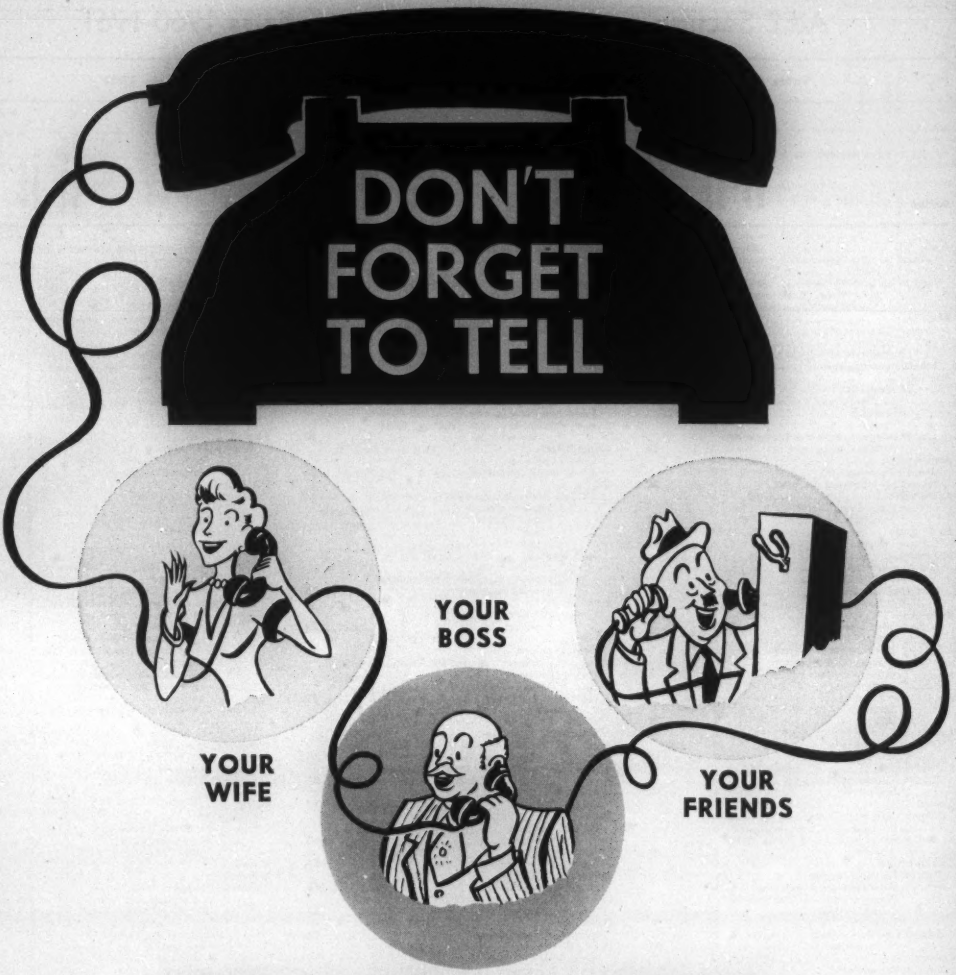
June 27-29, 1962
AIEE-AIChE-IRE-ISA-ASME
Joint Automatic Control Conference
New York University
New York, N. Y.
(Final Text due Nov. 15.)

August 13-16, 1962
Pacific Energy Conversion Conference
Fairmont Hotel
San Francisco, Calif.
(Final date for TP—May 14, CP Syn.—May 29, CPMs—June 8.)

August 27-September 1, 1962
IFIPS Congress
Munich, Germany

* District Paper Synopses should be directed to the District Meeting Committee

† Final date for submitting papers—closed



YOU'RE PLANNING TO ATTEND THE
ELECTRICAL ENGINEERING EXPOSITION
HELD IN CONJUNCTION WITH
AIEE WINTER GENERAL MEETING
NEW YORK COLISEUM – JANUARY 29 – FEBRUARY 2, 1962

FEATURING

EXHIBITS • TECHNICAL SESSIONS • COMMITTEE MEETINGS

INSPECTION TRIPS • SOCIAL ACTIVITIES • ENTERTAINMENT

AIEE Section and Student Branch Meetings 1960-1961

Table I. Section Membership, August 1961; Section Meetings During Year Ending April 30, 1961

Section	AIEE Members August 1961	Number of Meetings	Total Number of Meetings
Akron	265	7	
Groups: Industrial Application		3	
Power		4	
Joint Meeting: Power and Cleveland Section Power Generation and Transmission Group		1	15
Alabama	419	13	
Groups: Communications		8	
Industrial		3	
Power		9	
Subsection: Montgomery		9	42
Arizona	355	7	
Groups: Computer		4	
Electronics and Communications		5	
Industrial		1	
Power		8	
Joint Meetings: Section and Southern Arizona Section		3	28
Arkansas	168	10	
Group: Technical		1	
Subsection: Northwest Arkansas		9	20
Arrowhead	85	9	
Groups: Communications		2	
Mesaba Range Industrial		7	18
Baton Rouge	112	11	
Group: Technical		6	17
Beaumont	145	11	
Group: Technical		1	
Subsection: Lake Charles		6	
Joint Meeting: Section and Lake Charles Subsection		1	19
Boston	1,346	8	
Groups: Basic Science		2	
Computer		2	
Electronics and Communications		3	
Engineering Management		1	
Industrial Systems		3	
Instrumentation		2	
Nucleonics		1	
Technical		3	
Utility		4	29
Canton	118	8	
Groups: Electronics-Instrumentation		1	
Power		3	12
Central Florida	246	5	
Groups: Communications		3	
Power		4	12
Central Illinois	246	11	
Groups: Springfield Technical		4	
Technical		1	
Joint Meeting: Section and Illinois Valley Section		1	17
Central Indiana	449	9	
Groups: Electrical Heating		5	
Instruments and Measurements		4	
Power Transmission and Distribution Systems		6	
Technical		1	
Subsections: Bloomington		7	
Evansville		9	41
Chicago	2,318	5	
Groups: Basic Science		2	
Communications		1	
Electronics		2	
Industrial		3	
Power		3	
Student Activities		1	
Young Engineers		2	
Subsections: Calumet		4	
Fox Valley		4	
Joint Meetings: Basic Science and Power		1	
Communications and Industrial		1	
Communications and Electronics		1	
Electronics and Industrial		1	
Section, Industrial and Power		1	32
Cincinnati	407	8	
Group: Technical		1	9
Cleveland	1,209	7	
Groups: Analog Computer and Control		1	
Basic Science		2	
Construction		1	
Control Systems and Simulation		4	
Digital Computer		5	
Electrical Installation		5	
Electronics, Communications and Instrumentation		6	
Management		4	
Motor and Control		6	
Power Generation and Distribution		4	
Joint Meetings: Basic Science and Comm., Electr., Instrum.		2	
Basic Science and Power Gen. and Distr.		1	
Power Gen. and Distr. and Akron Sec. Power		1	
Section and Basic Science		1	50
Columbus	355	9	
Group: Industrial and Utility Power Systems		1	
Subsections: Chillicothe		6	
Newark		6	
Zanesville		9	
Joint Meetings: Chillicothe and Scioto Valley Subsections		2	33
Connecticut	1,019	8	
Groups: Communications		2	
Electric Power Generation, Transmission and Distrib.		3	
Electrical Measurements and Controls		1	
Industrial Electronics		1	
Industrial Power Applications		4	
Management		2	
Subsection: New London		8	
Joint Meeting: Electrical Meas. and Cont. and Industrial Elect.		1	30
Corpus Christi	118	11	
Group: Technical		1	
Subsection: Victoria-Port Lavaca		9	21
Dayton	344	6	
Groups: Electronics and Semi-Conductors		2	
Industrial Control		1	
Instrumentation		1	
Power		2	
Rotating Machinery		2	
Joint Meetings: Industrial Control and Instrumentation		3	
Section and Servo-Mechanisms and Computers		1	18
Delaware Bay	181	11	
Groups: Electronics		5	
Power		5	21
Denver	643	8	
Groups: Aeronautical		5	
Communications and Electronics		4	
Equipment		5	
Power		5	
Subsection: Black Hills		6	33
East Tennessee	390	12	
Group: Chattanooga Technical		5	
Subsections: Huntsville		5	
Muscle Shoals		6	
Upper East Tennessee		7	
Joint Meetings: Section and all Subsections		1	
Section and Oak Ridge Section		1	37
El Paso	147	14	
Group: Technical		3	17
Erie	220	7	
Groups: Computer		2	
Management		1	10
Florida West Coast	313	15	
Group: Distribution		6	21
Fort Wayne	193	13	
Subsection: Marion		5	18
Georgia	450	9	
Subsection: Rome		8	17
Gulf Coast	172	12	
Subsection: Panama City		6	18
Hamilton	214	12	
Subsections: Guelph		6	
London		7	
Joint Meetings: Section and Toronto Section		1	
Section, Subsections, Toronto Section		1	27
Hampton Roads	114	2	2
Hawaii	126	9	
Group: Technical		8	17
Houston	468	9	
Groups: Industrial Application		7	
Power		2	
Systems and Controls		4	
Subsection: Freeport		4	
Joint Meetings: Industrial Application and Power		1	
Power and Systems-Controls		1	28
Hudson Valley	324	9	9
Idaho	98	8	
Groups: Industrial Applications		1	
Southern Idaho Science and Electronics		1	
Subsection: Southern Idaho		10	20
Illinois Valley	105	11	
Groups: Electronic		2	
Power		4	17
Iowa	202	9	
Group: Power Application and System		5	
Subsection: Siouxland		4	18
Iowa-Illinois	196	9	
Subsection: Cedar Valley		10	19
Ithaca	367	4	
Group: Technical		1	
Subsection: Binghamton Area		5	
Joint Meetings: Section and Binghamton Area Subsection		2	12
Jacksonville	177	10	
Group: Power		6	
Subsection: Gainesville		8	
Joint Meeting: Section and Gainesville Subsection		1	25
Johnstown	100	12	
Group: Altoona Technical		5	17
Kansas City	439	11	
Groups: Industrial and Petroleum		1	
Power Generation, Transmission and Distribution		3	15
Lehigh Valley	510	11	
Groups: Allentown Technical		10	
Bethlehem Technical		3	
Easton Technical		2	
Hazleton Technical		3	
Reading Technical		7	
Scranton Technical		6	
Wilkes-Barre Technical		3	45
Lima	159	9	
Groups: Aeronautical		4	
Feedback Control Systems		3	
Motors and Controls		5	21
Los Angeles	3,015	4	
Groups: Basic Sciences		3	
Electronics		5	
Industry and Construction		4	
Magnetics		5	
Power		7	
Radio		6	
Teletype, Telegraph, Telemetering and Data		5	
Wire and Carrier		7	
Subsections: Boulder City		5	
Channel Counties		7	
Orange County		6	
Riverside-San Bernardino		7	
Joint Meetings: Basic Sciences and Management		1	
Channel Counties, Orange County, Riverside-San Bernardino		1	73
Louisville	252	8	
Groups: Communications, Science and Electronics		8	
Power		3	
Subsection: Lexington		6	25
Lynn	305	10	
Group: Illumination		2	
Subsection: Merrimack Valley		8	20
Madison	95	6	6
Maine	124	7	
Groups: Androscoggin Valley Technical		2	
Aroostook County Power		6	
Augusta Technical		5	
Portland Power		4	24
Mansfield	126	7	7
Maryland	990	8	
Groups: Aberdeen Area		1	
Aerospace		5	
Automatic Controls		6	
Communications		3	
Industrial Electronics		6	
Management		2	
Power		4	
Solid State		3	
Subsection: Eastern Shore		8	46
Memphis	157	8	
Group: Transmission and Distribution		4	
Subsection: Jackson		7	19
Mexico	190	10	
Subsection: Monterrey		0	10
Miami	276	12	
Subsection: Palm Beach		12	24
Michigan	1,114	6	
Groups: Communications		4	
Industry		4	
Power		7	
Professional Development		2	
Science and Electronics		3	26
Middle Tennessee	93	16	
Groups: Computer		5	
Instruments and Measurements		4	
Power System Engineering		7	32
Milwaukee	985	8	
Groups: Basic Science		2	
Computers		3	
Electric Machinery		3	
Electronics		2	
Power Application and Control		1	
Transmission and Distribution		3	
Subsection: Racine-Kenosha		2	
Joint Meeting: Section and Racine-Kenosha Subsection		1	25
Minnesota	537	9	
Subsection: Red River Valley		9	18
Mississippi	118	10	
Groups: Communications		9	
Power		8	27
Montana	121	2	
Group: Butte Subsection Technical		2	
Subsections: Billings		9	
Butte		9	

Section	AIEE Members August 1961	Number of Meetings	Total Number of Meetings
Helena		8	30
Montreal	662	15	
Group: Technical		3	
Subsection: Quebec		8	
Joint Meeting: Quebec Subsection and St. Maurice Valley Sec.		1	27
Nashville	106	8	
Groups: Communications		1	
Power		2	11
Nebraska	266	10	
Groups: Application and Industry		4	
Communications and Electronics		9	
Power Apparatus and Systems		7	30
New Hampshire	187	10	
Group: Technical		3	13
New Orleans	295	9	
Groups: Basic Science and Electronics		3	
Communications		1	
Power System Analysis		7	20
New York	5,792		
Groups: Basic Science		4	
Communications and Electronics		7	
Illumination		4	
Instrumentation		4	
Marine		3	
Land		4	
Power and Industrial		14	
Subsection: New Jersey Div.		7	
Joint Meetings: Basic Science and Communications		1	
Communications, P. and I, Transport		1	
Section and Communication and Elect.		2	51
Niagara Frontier	393	6	
Groups: Digital Computers		3	
Motor and Control		*4	
Technical		2	
Joint Meeting: Section and Niagara International System		1	16
Niagara International	150	11	
Group: Technical		1	
Joint Meeting: Section and Niagara Frontier Section		1	13
North Alabama	179	3	
Subsection: Muscle Shoals		3	6
North Carolina	638	2	
Groups: Charlotte Communications		6	
Charlotte Industrial Power & Control		7	
Charlotte Substation, Transmission and Distribution		7	
Eastern North Carolina Research		3	
Subsections: Charlotte		10	
Eastern North Carolina		8	
Mid-State		9	
Western North Carolina		7	
Joint Meeting: Eastern N. C. Subsection and E. N. C. Research		1	60
North Texas	790	8	
Groups: Central Texas Technical		3	
Electronics and Communications		2	
Industrial		3	
Power Generation and Rotating Machinery		4	
Relays, Protective Devices and Carrier Current		1	
Student		1	
Substations, Distribution, Switchgear and Transformers		4	
System Engineering and Transmission		3	
Subsections: Central Texas		5	
Fort Worth		6	
West Central Texas		8	
Joint Meetings: Section and all Subsections		1	
Relays-Prot. Dev.-Carrier Cur. and System Eng. and Trans.		1	
Section and Student group		1	51
Northeastern Michigan	148	10	10
Northeastern Wisconsin	126	11	11
Northern New Mexico	200	3	
Subsection: Los Alamos-Santa Fe		5	8
Oak Ridge	88	9	
Group: Technical		2	
Joint Meeting: Section and East Tennessee Section		1	12
Ohio Valley	66	11	
Group: Technical		2	
Joint Meetings: Scioto Valley and Chillicothe Subsections		7	20
Oklahoma City	216	9	
Groups: Communications		5	
Industrial Practices		5	
Power		7	
Professional Development		4	30
Ottawa	127	12	
Group: Power		4	16
Panhandle Plains	142	9	9
Philadelphia	2,220	11	
Groups: Aero-Space		3	
Basic Science		1	
Communications		5	
Computer		4	
Electronics		1	
Industrial Practices		4	
Management		5	
Measurements and Controls		5	
Power Systems		4	
Subsection: Atlantic City Div.		9	
Joint Meeting: Basic Science and Communications		1	53
Pittsburgh	1,635	13	
Group: Instrumentation		1	
Subsections: Centre County		8	
Upper Monongahela		5	27
Pittsfield	375	13	13
Portland	545	15	
Groups: Communications and Electronics		2	
Computer		1	
Industrial		3	
Power		5	
Technical		1	
Transportation, Instruments and Safety		1	
Subsections: Eugene		3	
Medford		3	
Joint Meetings: Section and Richland Section		2	
Section and Eugene Subsection		1	37
Providence	275	12	
Groups: Electronics		1	
Power Distribution		2	
Subsection: Southern Massachusetts		5	20
Richland	146	6	
Groups: Solid State Devices		3	
Technical		2	
Subsection: Walla Walla		5	
Joint Meetings: Section and Portland Section		2	
Section and Walla Walla Subsection		2	20
Ridgway	69	8	8
Rochester	345	15	
Groups: Communications and Electronics		3	
Power and Industry		3	21
Rock River Valley	145	10	10
Sacramento	258	11	
Groups: Electronics		4	
General Applications		2	
Transmission and Distribution		4	
Subsection: San Joaquin		6	27
St. Louis	832	15	
Groups: Power Practices		7	
Solid State Physics		6	
Subsection: Eastern Division		7	35
St. Maurice Valley	50	6	
Joint Meeting: Section and Quebec Subsection		1	7
San Diego	322	9	
Groups: Aerospace-Electronics		3	
Communications		6	
Electronics		1	
Management		1	
Utility		6	
Joint Meeting: Electronics and Aircraft-Missiles		1	27
San Francisco	1,920	8	
Groups: Communications		4	
General Applications		3	
Industrial		5	
Instrumentation		2	
Power		6	
Science and Electronics		2	
Subsections: Fresno		7	
Reno		8	
Santa Clara Valley		8	
Shasta		7	
Joint Meetings: Industrial and Power		1	61
Savannah	55	8	8
Schenectady	826	10	
Groups: Technical		7	
Technical Group of Adirondack Subsection		1	
Subsection: Adirondack		5	23
Seattle	917	9	
Groups: Aeronautical		4	
Basic Sciences		3	
Industrial		2	
Management		1	
Power		1	
Subsections: Alaska		4	
Tacoma		9	
Joint Meetings: Section and Tacoma Subsection		1	
Section and Power		1	35
Sharon	247	8	8
Shreveport	181	9	
Groups: Digital Computer		5	
Management		1	
Transmission and Relay		2	
Subsection: Monroe		8	
Joint Meeting: Section and Monroe Subsection		1	26
South Bend	126	6	
Groups: Basic Sciences		1	
Electronics and Solid State Devices		3	
Lighting		3	
Motors and Controls		2	
Power and Distribution		3	
Professional Development		1	19
South Carolina	258	2	
Subsections: Central Savannah River		10	
Charleston		8	
Columbia		10	
Piedmont		11	41
South Texas	153	16	16
Southern Arizona	87	9	
Groups: Electronics and Communications		1	
Industrial		1	
Power		1	
Joint Meetings: Section and Arizona Section		2	14
Spokane	227	12	
Groups: Applications and Industry		4	
Communications and Electronics		3	
Power, Transmission and Distribution		5	
Subsection: Wenatchee		6	30
Springfield	124	8	
Groups: Electronics		4	
Industrial Control		3	
Power		4	19
Susquehanna	152	11	
Group: Technical		7	18
Syracuse	518	7	
Groups: Industrial Systems		2	
Power		3	
Technical		1	
Subsection: St. Lawrence International		7	20
Toledo	194	15	
Groups: Electronics		3	
Industrial Practices		3	
Power		3	24
Toronto	734	12	
Groups: Communications		4	
Toronto Supper Club		9	
Joint Meetings: Section and Communications		1	
Section and Hamilton Section		2	28
Tulsa	238	10	
Groups: Aeronautical		2	
Basic Science		1	
Communications		1	
Computer		1	
Industrial Power		3	
Instrumentation and Control		1	
Management and Safety		2	21
Utah	163	3	
Group: Technical		5	8
Vancouver	305	19	
Groups: Industrial		4	
Power Systems		8	31
Vermont	60	7	
Groups: Burlington Technical		3	
Northeast Vermont Technical		3	
Power System Engineering		1	
Springfield Technical		2	16
Victoria	80	10	
Groups: Power Generation		2	
Transmission and Distribution		1	13
Virginia	291	1	
Subsections: Blue Ridge		8	
Hampton Roads		6	
Richmond		7	22
Virginia Mountain	275	8	8
Washington	1,144	7	
Groups: Feedback Control		1	
Computers		1	
Electronics and Basic Science		1	
Generating		2	
Industrial Light, Power and Control		6	
Instrumentation and Telemetry		3	
Communications Switching		1	
Management		2	
Nucleonics		1	
Protection		1	
System Engineering		1	
Technical		1	28
West Michigan	130	8	8
West Virginia	140	9	9
Wichita	214	11	
Group: Technical		6	17
Worcester	140	6	
Groups: Insulated Conductor		2	
Transmission and Distribution		2	10
	52,264	2,659	

Total sections, 119

Total technical groups, 277

Total subsections, 77

Table II. Branch Meetings Held During Year Ending April 30, 1961

Branches	Number of Meetings
*Air Force Institute of Technology	7
*Akron, University of	7
*Alabama, University of	12
*Alaska, University of	7
*Alberta, University of	6
Arizona State University	10
*Arizona, University of	5
*Arkansas, University of	6
Auburn University	12
Bradford Durfee College of Technology	14
*Bradley University	5
*Bridgeport, University of	4
Brigham Young University	10
*British Columbia, University of	19
*Brooklyn, Polytechnic Institute of (day)	7
*Brooklyn, Polytechnic Institute of (eve)	4
*Brown University	4
*Bucknell University	14
Buffalo, University of	11
*California Institute of Technology	4
California State Polytechnic College	11
*California, University of	23
*Carnegie Institute of Technology	5
*Case Institute of Technology	7
*Catholic University of America	4
Christian Brothers College	8
*Cincinnati, University of	11
*Clarkson College of Technology	2
*Clemson A and M College	11
*Colorado State University	8
*Colorado, University of	11
*Columbia University	10
*Connecticut, University of	6
*Cooper Union	9
*Cornell University	2
*Dayton, University of	4
*Delaware, University of	5
*Denver, University of	21
*Detroit, University of	13
*Drexel Institute of Technology	8
*Duke University	8
Penn College	32
*Florida, University of	7
Gannon College	9
*George Washington University	9
Georgia Institute of Technology	7
*Houston, University of	16
*Howard University	7
*Idaho, University of	12
Illinois Institute of Technology	13
*Illinois, University of	
Chicago Division	10
*Iowa State University	18
Iowa, State University of	23
*Johns Hopkins University	14
Kansas State University	13
*Kansas, University of	4
Kentucky, University of	6
*Lafayette College	9
*Lamar State College of Technology	5
Laval University	9
*Lehigh University	6
*Louisiana Polytechnic Institute	10
*Louisiana State University	5
*Louisville, University of	9
*Maine, University of	8
*Manhattan College	13
*Marquette University	10
*Maryland, University of	7
*Massachusetts Institute of Technology	6
*Massachusetts, University of	7
*Merrimack College	4
Miami, University of	10
*Michigan College of Mining and Technology	7
*Michigan State University	6
*Michigan, University of	10
Milwaukee School of Engineering	8
*Minnesota, University of	7
Mississippi State University	11
*Missouri School of Mines and Metallurgy	9
*Missouri, University of	7
*Montana State College	12
*Nebraska, University of	9
*Nevada, University of	6
Newark College of Engineering	2
New Bedford Institute of Technology	27
*New Hampshire, University of	7
*New Mexico State University of Agriculture, Engineering and Science	9
*New Mexico, University of	5
New York, College of the City of	21
*New York University (day)	6
*New York University (eve)	5
*North Carolina State College	9
*North Dakota State College	8
*North Dakota, University of	13
*Northeastern University	14
*Northwestern University	37
*Norwich University	7
*Notre Dame, University of	6
*Ohio Northern University	8
*Ohio State University	9
*Ohio University	7
*Oklahoma State University	7
*Oklahoma, University of	8
Oregon State College	15
*Pennsylvania State University	9
*Pennsylvania, University of	19
Pittsburgh, University of	24
Prairie View A and M College	9
*Pratt Institute	14
*Princeton University	5
Puerto Rico, University of	1
*Purdue University	8
*Rensselaer Polytechnic Institute	7
*Rhode Island, University of	7
*Rice Institute	6
*Rose Polytechnic Institute	5
*Rutgers University	19
St. Louis University	5
*San Francisco State College	6
*San Jose State College	8
*Santa Clara, University of	7
*Seattle University	9
*South Carolina, University of	7
South Dakota School of Mines and Technology	8
*South Dakota State College	11
*Southern California, University of	14
*Southern Methodist University	9
Southwestern Louisiana Institute	5
*Stanford University	6
*Stevens Institute of Technology	5
*Swarthmore College	5
*Syracuse University	6
Tennessee Polytechnic Institute	20
*Tennessee, University of	12
Texas College of Arts and Industries	3
*Texas, A and M College of	11
*Texas Technological College	13
*Texas, University of	7
Texas Western College	8
*Toledo, University of	16
*Toronto, University of	3
*Tufts University	5
*Tulane University	8
*Union College	8
U. S. Naval Post Graduate School	10
Utah State University	13
*Utah, University of	16
Valparaiso University	5
*Vanderbilt University	14
*Vermont, University of	1
*Villanova University	10
Virginia Military Institute	16
*Virginia Polytechnic Institute	12
*Virginia, University of	7
*Washington State University	8
*Washington University	6
*Washington, University of	13
*Wayne State University	9
West Virginia Institute of Technology	13
*West Virginia University	6
Wichita, University of	7
*Wisconsin, University of	9
*Worcester Polytechnic Institute	5
*Wyoming, University of	14
*Yale University	2
*Youngstown University	7

Total Branches 167
*Joint AIEE-IRE 127

8th National Symposium on Reliability and Quality Control To Be Held January 9-11

The 8th National Symposium on Reliability and Quality Control is scheduled for January 9-11, 1962, at the Statler Hilton Hotel in Washington, D. C.

Thirteen technical sessions and a panel discussion in which leaders from the military service and industry will participate are on the conference program. Technical sessions will cover ten major areas of interest, as follows:

1. Reliability and design techniques
2. Reliability prediction and measurement
3. Mathematics and reliability models
4. Statistical techniques
5. Reliability testing
6. Maintainability
7. Quality control and reliability
8. Reliability programs and management
9. Reliability and quality control education
10. Reliability training sessions

The 54 papers to be presented were selected from 173 submittals. The papers to be given at the symposium are:

Precision through Variations Flow Analysis
N. L. Enrick, Univ. of Va.

A Missile Reliability Reporting System
I. R. Whiteman, C-E-I-R

Reliability Management by Objectives and Results
L. W. Ball, Boeing Airplane Co.

Weibell Plans for Failure Rate and Quantile Life
K. Goode, H. P. Goode, Cornell Univ.

Full Design Definition is Essential to Reliability
W. L. Hurd, Jr., Lockheed Aircraft Corp.

Reliability Research on Components for Space
E. E. Brueschke, Hughes Aircraft Co.

A Survey of Practical Statistical Tools for Reliability Measurement and Acceptance
C. M. Ryerson, Ryerson Associates

General Usage Assemblies for Navy Electronic Equipment
T. E. McDuffie, G. C. Neuschaefer
U. S. Naval Material Lab.

Contractural Reliability—An Education Program
R. H. Johnson, Martin Co.

The Problem of Human Initiated Failures
David Meister
General Dynamics Astronautics Reliability Program Requirements for Aerospace Systems and Subsystems
Maj. V. J. Bracha, USAF

Optimum Reliability Testing for Space Systems
Mrs. C. D. Hock, NASA

Statistical Independence in Reliability Equations
A. M. Breipohl, Sandia Corp.

Reliability and Forced Air Cooling
J. L. Keller, S. D. Olicker
Sperry Gyroscope Co.

Aspects of an Effective Reliability Program Documented by Advanced Bombing-Navigation System Reliability Experience
F. W. Blackburn, A. M. Letow
Sperry Gyroscope Co.

Estimating Guided Missile System Reliability from R & D Systems Firing Tests
Alvin Steinberg, Army Rocket and Guided Missile Agency, U.S. Army Ordnance Missile Agency

Assuring the Quality of Nuclear Weapons
C. E. Smith, Jr., Sandia Corp.

Analysis Testing for Improved Circuit Reliability
B. J. Grinnell, IBM

Truncation of Sequential Life Tests
T. L. Burnett, Endicott, N.Y.

Determination and Use of Failure Patterns
R. L. Horn, Boeing Airplane Co.

A Reliability Slide Rule
Benjamin Ellison, Victor Selman
Int'l Elec. Corp.

Statistical Methods as Design Tools
Col. L. A. Rowell, USAF

Reliability Through Process Capability Studies
G. O. Hawley, Albuquerque, N. Mex.

Process Acceptance Vs. Lot Acceptance
C. R. Clark, F. W. Muller, Sandia Corp.

Some Considerations of Scheduled Maintenance
Richard Meyers, Int'l Elec. Corp.

Component Part Lifetimes Related to a Satellite Environment

D. R. Earles, AVCO Corp.

Methodology for System Reliability Analysis
Bernard Tiger, M. J. Smith
Norden Div. of United Aircraft Corp.

Increasing Reliability Through the QUAD Technique
R. M. Fasano, Sylvania Elec. Products

Management of Equipment Reliability Activities at USASRDL
T. J. Edwards, H. M. Nachmias
U.S. Army Signal Research & Development Lab.

Martin-Denver Auto QC
R. A. Bennett, Martin Co.

Reliability Emphasis on Production Contracts
J. A. Marshik
Minneapolis-Honeywell Regulator Co.

Determining Confidence Limits for the Reliability of a System for Tests on Components
W. S. Connor, W. T. Wells
Research Triangle Inst.

Acceleration Factor Determination on Glass Capacitors
L. D. Hines, Corning Glass Works

Operational Reliability of the Athena Computer
G. P. Anderson, Remington Rand Univac, Div. of Sperry Rand Corp.

QC Management for Time-Compressed R & D Programs
F. A. Barta, Hughes Aircraft Co.

Pert-Pep Controls for Reliability and Costs
H. G. Romig, Pacific Palisades, Calif.

Maintainability Prediction and Measurement
R. A. Miles, B. L. Retterer, RCA Service Co.

Development of New Prediction Techniques
I. Bosinoff, J. Klion
Sylvania Electronic Systems, Waltham Labs.

A Comprehensive Education and Training Program for Design Reliability
R. A. Henning, Boeing Airplane Co.

Failure Analysis
E. W. Kimball, Martin Co.

Screening for Critical Variables Affecting Reliability
C. H. Li, General Instrument Corp.

Mathematical Analysis of Redundant Matrices
G. D. Weinstock, ITT Labs.

Practical Aspects of a High Reliability Specification
John Sand, T. W. Gross
Lockheed Aircraft Corp.

Simulation of Aircraft Electronics Maintenance
D. S. Ellis, V. G. Maxon, B. Seid
Hughes Aircraft Co.

Factorial Experiments in Reliability Analysis
C. L. Barron
Minneapolis-Honeywell Regulator Co.

Effective Reliability—Through Education
P. H. Zorger, Martin Co.

Reliability Evaluation by Application Derating
K. W. Davidson, Texas Instruments

Equipment Self-Repair Techniques
Jerome Klion, Rome Air Development Center

The Life Distribution and Reliability of Electromechanical Parts of an Inertial Guidance System
L. A. Weaver, M. P. Smith, Minneapolis-Honeywell Regulator Co.

CAMESA Reliability Test Program
A. P. Harris
Canadian Military Electronics Standards Agency

Reliability Predictions for Multi-Mode Electronic Systems
J. A. Conner, Astro Reliability Corp.

The Human Element in the Maintenance Package
H. W. Page, IBM

AGREE in Action; Correlation of AGREE Testing with Operational Reliability
G. W. Lindsay, USAF

The activities and technical papers from the National Symposia held each year on Reliability and Quality Control have been recorded in *Proceedings*, which presents a valuable record of the development of the art. It is published through the sponsorship of the Institute of Radio Engineers. Copies of the *Proceedings*, available for the last seven symposia may be obtained at $5.00 each, postpaid, from the Editorial Department of the Institute of Radio Engineers, 1 East 79th Street, New York 21, N. Y.

Cosponsors of the Symposium comprise AIEE, the American Society for Quality Control, Institute of Radio Engineers, and Electronics Industries Association.

The Management Committee for the Symposium includes the following: General chairman—M. P. Smith, Minneapolis-Honeywell; vice-general chairman—R. E. Kuehn, Institute for Defense Analyses; secretary—M. M. Tall, Radio Corporation of America, and treasurer—H. E. Reese, Burroughs Corporation.

United States Participation Fostered in Global Computer Congress

Plans are in the making for enthusiastic United States participation in IFIP Congress 62, the 2nd international congress on information processing, to be held in Munich, Germany, from August 27 to September 1, 1962, under the sponsorship of the International Federation of Information Processing Societies (IFIPS). The United States member of IFIPS is the American Federation of Information Processing Societies (AFIPS), newly formed from the Joint Computer Committee established 10 years ago by AIEE, the Institute of Radio Engineers and Association for Computing Machinery.

The IFIP Congress 62 will continue the activities of the International Conference on Information Processing, sponsored by UNESCO in Paris, France, June 1959. The purpose of the forthcoming conference is to exchange information among the information technologists of all countries, thus promoting the information-processing sciences throughout the world. The Congress will feature numerous technical sessions in which the present status and new developments in the data-processing field will be reported by the specialists involved, together with an extensive exhibit of new equipment from all over the world.

EXECUTIVE COMMITTEE APPOINTED

Dr. E. L. Harder has been appointed chairman for the Committee for United States Participation. Dr. Harder, in turn, recently named an executive committee of which he is chairman, comprising I. L. Auerbach, president of IFIPS; Dr. A. S. Householder; Dr. W. F Bauer; Dr. D. L. Thomsen, Jr., in charge of U S. exhibits; Dr. Werner Buchholz, in charge of travel arrangements, and C. W. Adams, in charge of communications and publicity.

Dr. Harder, a vice-president of AIEE and a leading authority on computing equipment, is manager of the advanced systems engineering and analytical department of Westinghouse Electric Corporation in East Pittsburgh, Pa. In addition to co-ordinating this country's efforts to assure the fullest possible participation, Dr. Harder heads the United States Program Committee which will do preliminary screening of all contributed papers. His committee will also recommend to the international group the Americans who might best contribute as invited speakers and participants in the panels and symposia which will be features of the meeting.

Senior counselers Auerbach, Householder, and Bauer are all well known in the computer field. Mr. Auerbach is president of Auerbach Electronics Corporation, Dr. Householder is at Oak Ridge National Laboratory, and Dr. Bauer is manager, information systems department, of Ramo Wooldridge in Canoga Park, Calif.

TRAVEL ARRANGEMENTS

The man in charge of travel arrangements, Dr. Werner Buchholz, is systems consultant for the computer and engineering staff at International Business Machines (IBM) in Poughkeepsie, N. Y. Dr. Buchholz has reported that initial contacts have been made with airlines to reserve passage to Munich for those attending the Congress.

Dr. Thomsen, chairman of the Board of Trustees of the Society for Industrial and Applied Mathematics and special assistant to the director of education at IBM's New York headquarters, has been assigned to encourage and aid appropriate United States computing equipment manufacturers to exhibit their equipment in Munich. Dr. Thomsen stated his committee's objective: ". . . to present the most significant and up-to-date information processing equipment in the United States."

Responsibility for communications and public relations rests with C. W. Adams, president of the electronic data processing consulting firm of Charles W. Adams Associates, Inc., in Bedford, Mass. Up-to-date information will be provided on request to members of the sponsoring societies of AFIPS and other parties interested in the IFIP Congress 62. The address for further information is 142 the Great Road, Bedford, Mass.

Scintillation Symposium To Take Place in Washington

The 8th Scintillation and Semiconductor Counter Symposium will be held March 1-3, 1962, at the Hotel Shoreham, Washington, D.C. It is one of the series begun in 1948 and held biennially since then. These Symposia have been instrumental in bringing together those interested in these nuclear radiation detectors either as users or designers. Both the theoretical and practical aspects of the newer techniques, equipments, and components will be covered in invited and contributed papers by workers in the field.

The 8th Symposium will consist of five

daytime sessions covering the following topics:

1. Scintillators
2. Photomultipliers and Image Tubes
3. Counter Systems and Applications
4. Semiconductor Detectors
5. Scintillation Track Imaging and Spark Chambers

There will be an evening discussion session, preceded by a banquet, on March 1. A limited exhibition will display some of the latest equipment available in the scintillation and semiconductor counter field.

The AIEE, Atomic Energy Commission, Institute of Radio Engineers, and National Bureau of Standards are the sponsors of the Symposium. Further information can be obtained from G. A. Morton, chairman, Scintillation and Semiconductor Counter Symposium Committee, RCA Laboratories, Princeton, N. J.

Dr. Rüdenberg Receives Medal from Franklin Institute

Dr. Reinhold Rüdenberg (M'38, F'50), professor emeritus of Harvard University, whose engineering textbook and more than 300 patents have earned him a place in electrical engineering history, received an Elliott Cresson Medal from the Franklin Institute on October 18 at the Institute's annual Medal Day ceremonies.

The medal citation to Dr. Rüdenberg reads: "For his many contributions to the electric power industry for over 50 years as an engineer, inventor, author, and teacher, and particularly for his scholarly textbook on 'Transient Performance of Electric Power Systems' by which present and future engineers may attain a better understanding of the problems of their profession."

Dr. Rüdenberg's book was first published in German in 1923. After several editions had been published, in 1950 the text was translated into English. It is a standard reference in libraries of universities, utilities, electrical laboratories, and industrial organizations.

The engineer also contributed to the early development of the electron microscope and to the understanding of the basic mechanism of absorption of electric waves in receiving antennas.

Dr. Rüdenberg was Gordon McKay professor of electrical engineering at Harvard University from 1939 until his retirement in 1952.

The Elliott Cresson Medal is awarded annually by the Franklin Institute, to one or more persons for discovery or original research adding to the sum of human knowledge. The medal as an award was established in 1848 by Elliott Cresson of Philadelphia.

Reinhold Rüdenberg was born February 4, 1883, in Hannover, Germany. He was graduated from the Leibnitz-school in 1901, and from the Hannover Institute of Technology with a doctorate in engineering in 1906.

He was an instructor at Goettingen University during 1906-08, and an honorary professor in 1913-35 at the Berlin Institute of Technology.

In 1908, he became an electrical engineer for the manufacturing company of Siemens-Schuckertwerke, and subsequently was made chief electrical engineer. In 1936, as a result of the adverse conditions in Germany, he moved to London as a consulting engineer for the General Electric Company, Ltd. Three years later, he came to the United States and Harvard University. Since his retirement in 1952, Dr. Rüdenberg has been a visiting professor at the university of California in Berkeley and in Los Angeles; at the National University of Brazil at Rio de Janeiro and the University of Sao Paulo, Brazil; and at the University of Montevideo, Uruguay. Dr. Rüdenberg was awarded an honorary doctorate from Karlsruhe Institute of Technology in 1921; the Montefiore prize, Liège University, Belgium, 1911; Honor Award Medallion, Stevens Institute of Technology, 1946; Cedergren Medal and Scroll, Universities of Technology, Sweden, 1949. He was named Honorary Senator of the Berlin University of Technology, 1956, and was awarded a Commander's Cross of the Order of Merit of West Germany in 1957.

Dr. Rüdenberg holds membership in the American Physical Society, American Academy of Arts and Sciences, and the honor societies Sigma Xi and Eta Kappa Nu.

Engineering Library Provides Numerous Services

Outstanding in all fields of engineering, the Engineering Societies Library which is situated in the new United Engineering Center in New York is used throughout the world by those needing engineering information.

The library's 180,000-volume collection is primarily on the level of the graduate and practicing engineer. More than 3,400 periodicals and other serial publications are currently received from some 50 countries in 20 foreign languages.

The Reading Room is open to the public on Monday to Friday, from 10 a.m. to 9 p.m. and on Saturday from 10 a.m. to 5 p.m. Books may be borrowed in person or by mail by members of 12 founder and associate societies.

Loans are made to members in the continental United States and Canada. Periodical publications may not be borrowed. A book may be kept up to 2 weeks for a charge of 50 cents a week or fraction of a week, not counting time in transit, and return postage must be paid by the borrower. Books will be sent air parcel post, on request, with the postage to be paid by the borrower. Members may have three volumes on loan at one time. Rare books and reference books will be lent only after approval by the Library Board.

Literature searches are made for all purposes including that of disclosures related to patents.

Photoprints of library materials will generally be supplied as positive prints made by an electrostatic process. This method of reproduction, excellent for text, lines, and charts, is poor for most illustrations, for which another process such as diffusion transfer may be used.

Microfilm as supplied is 35 millimeters wide, and an enlarging device is required to read it.

Engineering and scientific articles may be translated from any foreign language into English at special rates for the service.

The Engineering Societies Library staff, of which R. H. Phelps is director, has prepared bibliographies on subjects of general engineering interest. A list will be sent on request.

Section Celebrates Anniversary

In celebration of its 10th anniversary, the Central Illinois Section, AIEE, designated its September 19th meeting as Past Chairmen's night. Nine of the ten Past Chairmen were present for the special anniversary part of the program. Past Chairmen in the group picture are: (Front row, left to right) *J. F. Kruszka (1951-52), J. Spengler (1952-53), C. L. Eletson (1954-55), and W. J. Kelley(1956-57).* (Back row, left to right) *J. W. Marquardt (1957-58), G. P. Wilson (1958-59), H. W. Griffith (1959-60), and J. O. Noel (1960-61). Not shown are: C. R. Schultz (1953-54) and G. E. Sangster (1955-56)*

Inquiries should be addressed to: Engineering Societies Library, 345 E. 47 St., New York 17, N. Y.

The Engineering Index, Inc., at this same address, prepares and publishes an index based on publications received in the Engineering Societies Library. The Index is available in the form of daily and weekly card services and annual volumes, sets of which are kept in libraries in many countries. Some 38,000 annotated references to bulletins, reports, and magazine articles were published last year. The library retains all of the indexed publications.

Employer's Inventory of Manpower Developed

Establishment of the Employer's Inventory of Critical Manpower, a new program endorsed and supported by the Director of Selective Service, which will safeguard the effective utilization of engineering and scientific manpower in the event of a national emergency, has been announced jointly by Dr. S. B. Ingram, chairman, Engineering Manpower Commission, and Col. D. O. Omer, Deputy Director of Selective Service.

According to Dr. Ingram, present safeguards are inadequate to prevent the wholesale withdrawal of engineering and scientific manpower from industry in a national emergency.

"The increasing importance of technological manpower in the event of armed conflict demands maximum utilization of engineering and scientific personnel whether in industry or in the armed services," Dr. Ingram stated. "We view with deepest concern present inadequate provision to prevent wholesale disruption of essential production and the slowing down of the rate of technological advance in the event of a sudden and substantial mobilization. The Employer's Inventory of Critical Manpower, developed by the Engineering Manpower Commission of Engineers Joint Council and the Scientific Manpower Commission. is an attempt to aid in the solution of this problem in the national interest."

"During past national emergencies, we have not had an optimum utilization of our skilled manpower," Dr. Ingram said. "Since 1953 vast technological strides have made it increasingly important that we avoid unnecessary and sudden disruption of engineering and scientific personnel."

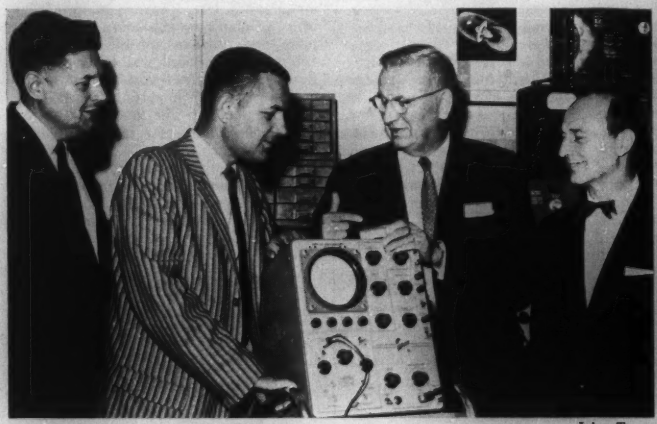
The Inventory program supplies condensed information on critical employees' liability to the draft and shows what will happen to a given company during mobilization. It identifies the balance between critical and noncritical personnel, subject to military service, and indicates a probable order of call to armed services during emergency.

It provides employers and Selective Service with a complete analysis of critical personnel problems through the collection and tabulation of relevant Selective Service data. The Engineering and Scientific Manpower Commissions will supply appropriate forms, and current information relative to the draft.

New Palm Beach Section Formed

B. V. Martin, District 4 Vice-President, presented a charter to the Palm Beach Section at a dinner meeting held August 23 at the Town House Motor Hotel in West Palm Beach, Fla. Shown at the presentation are (left to right) *J. V. Little, Secretary-Treasurer of the Section; H. C. Burnette, Section Chairman; Mr. Martin; and Earl Owen, Section Vice-Chairman. Chartered as a Subsection of the Miami Section on August 1, 1958, with 24 members, the Palm Beach Section now has a total membership of 67. The Section includes the seven Florida counties of Glades, Hendry, Indian River, Martin, Okeechobee, Palm Beach, and St. Lucie*

Miniature Timing Device Inspected



John Tyner

The Fox Valley Subsection of the Chicago Section, AIEE, started its season September 6 with a tour of the Research and Engineering Laboratories of the Elgin Micronics Midwest Division of the Elgin National Watch Company. Inspecting a miniature timing device are: (left to right) *C. L. Turner, manager of the laboratory; Subsection Chairman G. W. Austin of the Commonwealth Edison Company; P. H. Crago, chief project engineer, and Subsection Secretary W. G. Quist of the Automatic Electric Company*

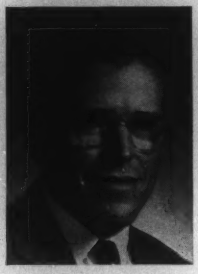
AIEE FELLOWS ELECTED

Board of Directors Meeting, August 21, 1961

Keats Abbott Pullen, Jr. (AM '42, M '48), electrical engineer, Ballistic Research Laboratories, Aberdeen Proving Ground, Md., has been transferred to the grade of Fellow in the AIEE ". . . for contributions through research and literature to design of control and information-gathering systems for missiles." Dr. Pullen was born November 12, 1916, in Onawa, Iowa. He received a B.S. degree in physics in 1939 from the California Institute of Technology and a Dr. Eng. degree in electrical engineering in 1946 from Johns Hopkins University. Since 1946, Dr. Pullen has been in the electronics branch of the Ballistic Measurements Laboratory, Ballistic Research Laboratories. During this period, he has contributed to the development of electronic tracking equipment for tracking both passive and active missiles and satellites. He has also engaged in research in the fields of network theory and information theory. Dr. Pullen has published four books dealing with the application of active devices in networks, of which the latest is *Handbook of Transistor Circuit Design*. He currently holds the rank of adjunct professor of electrical engineering at Drexel Institute of Technology. A registered professional engineer in the State of Maryland, he is a senior member of the Institute of Radio Engineers, a member of the Baltimore Engineers Club, and a member of Sigma Xi. Dr. Pullen has served as a member of the Executive Committee of the Maryland Section, AIEE (1958-61), is chairman of the Aberdeen Area subgroup of the Maryland Section, and is a member of the AIEE Electronics Committee.

K. A. Pullen, Jr.

Kenneth Dwight Beardsley (AM '31, M '47), development engineer, Distribution Transformer Advance Product Engineering, General Electric Company, Pittsfield, Mass., has been transferred to the grade of Fellow in the AIEE ". . . for contribution to the development of cores and magnetic materials for distribution transformer." Mr. Beardsley was born July 18, 1909, in Boston, Mass. He received B.S. and M. S. degrees in 1929 and 1930, respectively, from the Massachusetts Institute of Technology. Mr. Beardsley joined the Pittsfield Works Laboratory of General Electric in 1930. In 1941, he joined the distribution transformer department of General Electric and worked on the design of pole-type, station-type, and load-center transformers. He was later assigned to the design of pulse transformers for radar applications and was responsible for testing equipment and methods. In 1947, Mr. Beardsley began his work on transformer cores and core materials as a development engineer in the Advance Product Engineering Subsection of the General Electric Distribution Transformer Department. In this capacity, he has been responsible for the development of core materials, processing methods, and structures, and for studies of core characteristics. A registered professional engineer in the State of Massachusetts, Mr. Beardsley is a member of the National Society of Professional Engineers.



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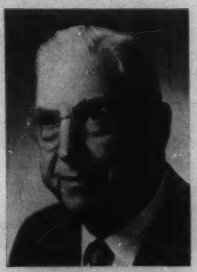
K. D. Beardsley

Edwin Diehl Manspeaker (AM '26, M '41), defense representative, General Electric Company, Wichita, Kans., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to service engineering of aircraft electrical systems." Born in Elwood, Nebr., on February 27, 1900, he was educated at the University of Kansas, from which he received a B.S. degree in electrical engineering in 1924. He joined General Electric that year as a student engineer and undertook graduate study at Union University while located at Schenectady, N. Y. In 1930, he was transferred to Jackson, Mich., where he was engaged in commercial work with electric utilities and their engineering consultants. In 1942, Mr. Manspeaker was appointed manager of the Wichita office, where he was assigned to the first remotely controlled gun turret installation made in aircraft and the first large production installation of jet engines in aircraft. He planned and supervised the Strother Field Jet Engine Modification Shop. Mr. Manspeaker was appointed to the position of defense representative in 1960 and is now responsible for liaison work with military installations and the aviation, defense, and electronics industries. A registered professional engineer in the State of Kansas, he is also a member of the Society of Automotive Engineers and the American Rocket Society.

Gustave Jean Charles Maryssael (M '46, former president of the Mexican Light and Power Company, Ltd., Mexico City, Mexico, has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the design and construction of a large public utility in Mexico." Mr. Maryssael was born October 1, 1903, in Verona, Italy, and is a citizen of Belgium. He graduated from the University of Brussels as a civil and mining engineer in 1926. The next year, he was awarded a degree in electrical engineering from the University of Ghent, and immediately afterward became assistant to the profes-



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E. D. Manspeaker

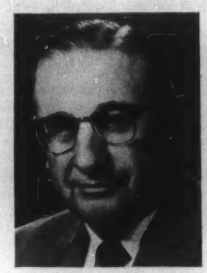
G. J. C. Maryssael

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grade, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 345 East 47th Street, New York 17, N.Y.

sor in the industrial electricity laboratory of that university. In 1929, he joined the Société Financière de Transports et d'Entreprises Industrielles (Sofina), S. A., in Brussels, Belgium. Mr. Maryssael was appointed general manager of the Mexican Light and Power Company in 1937, and subsequently became a director of the company, vice-president and, in 1949, president. As a consequence of the nationalization of the Mexican Light and Power Company in 1960, Mr. Maryssael left the concern and is now engaged in consulting work in Mexico. He was recently appointed a vice-president of Contimex, a newly organized company for the manufacture of Belgian electric meters in association with Mexican capital. Mr. Maryssael is a member of the Association des Ingénieurs Sortis de l'Ecole Polytechnique de Bruxelles and of the Asociación Mexicana de Ingenieros Mecánicos y Electricistas. He has also been appointed by his Government as advisor in Mexico for Belgian foreign trade.

L. S. Schwartz

Leonard Sidney Schwartz (AM '45, M '48), project director and adjunct professor, Electrical Engineering Department, New York University, Bronx, N. Y., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the theory of communication systems." Mr. Schwartz was born May 28, 1914, in Pittsburgh, Pa. He was educated at the University of Pittsburgh from which he obtained a B.S. degree in physics and mathematics in 1936 and an M.S. degree in physics in 1939. While an officer in the military service during World War II, he was engaged in radar research and development at the Radiation Laboratory of the Massachusetts Institute of Technology and later at the Naval Research Laboratory. After the war, he remained at the Naval Research Laboratory as a civilian radio engineer. In 1947, he joined the Hazeltine Electronics Corporation to work on radar developments and held the position of supervising engineer. In 1952, he joined the Research Division of the College of Engineering of New York University where he has been directing projects concerned with applications of communication theory. Mr. Schwartz is also a research consultant. For several years, he has been teaching advanced graduate courses in information theory, noise analysis, and nonlinear circuit analysis both at New York University and at Adelphi College, in Garden City, N. Y. Mr. Schwartz is presently co-authoring the book, *Theory of Digital Communication Systems*, to be published by McGraw-Hill. He is a Fellow of the Institute of Radio Engineers, and a member of the American Mathematical Society, Sigma Pi Sigma, Sigma Xi, and Eta Kappa Nu. Mr. Schwartz has served on the AIEE Communication Theory Committee (1957-61, chairman 1959-61) and Communication Division Committee (1959-61).



T. D. Thomas

Talmage DeWitt Thomas (AM '39, M '42), vice-president in charge of engineering, Texas Power and Light Company, Dallas, Texas, has been transferred to the grade of Fellow in the AIEE ". . . for contributions in guiding the design and construction of a large electric utility system." Mr. Thomas was born October 4, 1896, in Merit, Texas. He graduated from Rice Institute in 1920 with the B.S. degree in mechanical engineering, and has been employed by Texas Power and Light since 1920, except for a period during 1923-24 when he was loaned on detached service to a consulting engineer in Dallas. During the period 1920-26, he was on field construction, appraisal, and estimating work. In 1926, he was placed in charge of the Appraisal and Estimating Section, and in 1930, the Design Division. In 1939, he was made chief engineer of the company and, in 1957, vice-president in charge of engineering. A registered professional engineer in the State of Texas, Mr. Thomas is a member of the National Society of Professional Engineers and the Texas Society of Professional Engineers. He is a member of the Program Committee for the Power Distribution Conference of the University of Texas, and has served on the AIEE Industrial Power Applications Committee (1944-46).

George Harold Underhill (AM '21, M '27, Member for Life), deputy chief engineer, Central Hudson Gas and Electric Corporation, Poughkeepsie, N. Y., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the development of common neutral primary distribution aerial cable systems." Mr. Underhill was born August 30, 1899, in Poughkeepsie, N. Y. He graduated from Pratt Institute in 1919. In 1920, he joined Central Hudson Gas and Electric Corporation as a junior electrical engineer, where he was appointed, successively, to the positions of meter engineer, distribution engineer, and electrical engineer. He became system planning engineer in 1930, with responsibility for the long- and short-range planning of transmission, distribution, and street lighting system development, which led to an intensive program of rural line construction. He directed experimentation with advanced types of rural and urban distribution systems involving high-voltage single-conductor cable, high-conductivity messenger as the common neutral, and simplified transformer and line device mountings. In 1934, he was appointed assistant to the chief engineer, with responsibility for special studies and projects.

G. H. Underhill

In 1949, he was appointed deputy chief engineer, responsible for engineering management and administrative functions, including direction of the Planning Division. Mr. Underhill is a member of the Institute of Radio Engineers, National Society of Professional Engineers, and a company representative member of the International Conference on Large Electric High Tension Systems, American Society for Engineering Education, and Atomic Industrial Forum. He is an honorary member of the National Committee for Utilities Radio, a licensed professional engineer in New York State, and a member of the National Society of Professional Engineers.

Fellows are elected *by the Board of Directors from among Members. Technical Qualifications—Nominee must be an engineer or scientist who has attained distinction as: (a) Engineer in design, construction, operation or manufacturing; (b) Educator teaching a major course in an electrical engineering or science curriculum approved by the Board of Directors; (c) Originator of distinctive inventions or original work in electrical science, arts or literature; and (d) Engineering Executive of electrical engineering work of large scope, or who has applied electricity to important engineering projects.*

MEMBERS IN THE NEWS

C. T. Abbott (AM '41, M '47), a vice-president of the NEGEA Service Corporation of the New England Gas and Electric system, Cambridge, Mass., has become executive vice-president of the company.

D. C. Alexander (AM '44, M' 51), chief engineer of the Surprenant company, a subsidiary of International Telephone and Telegraph Corporation, New York, N. Y., has been elected vice-president—engineering.

O. L. Angevine, Jr. (AM '37, M '43) was recently appointed chief engineer of the Progress Webster Corporation, Rochester, N. Y. He was formerly a vice-president and chief engineer of the Caledonia Electronics and Transformer Corporation, Caledonia, N. Y.

A. M. Barbella (AM '52), staff engineer of Instruments for Industry, Inc., Hicksville, N. Y., has been promoted to chief systems engineer.

J. M. Bernstein (AM '59), formerly supervisor of Electronic Switching Techniques for Automatic Electric Laboratories, Inc., Northlake, Ill., has been appointed staff engineer for systems with the Automatic Electric Sales Corporation.

Ray Blain (AM '24, M '31), chief engineer of the U. S. Army Signal Engineering Agency, Arlington, Va., retired August 31 after 43 years of continuous service with the Army Signal Corps. He has also been employed as technical editorial director of *Telephony*, a telephone industry journal, since 1941. In retirement, his efforts will be devoted to his editorial duties.

Hal Borgen (AM '61) has been elected president of Colin Campbell Company of Danbury, Conn. He was formerly manager of product development, Instruments for Industry, Hicksville, N. Y.

J. D. Bowen (AM '53) has been named sales manager for the Sorensen product lines of Raytheon Company, South Norwalk, Conn. Mr. Bowen was formerly a sales engineer for Sorensen & Company, Inc., before the firm was acquired by Raytheon in 1959.

G. S. Brown (AM '33, F '50), dean of engineering at the Massachusetts Institute of Technology, has been elected to the Board of Overseers of the Thayer School of Engineering at Dartmouth College. This will be Professor Brown's second 4-year term. He has served on the AIEE Education Committee (1958-61).

G. W. Clothier (AM '36, M '42) has been appointed to the new post of manager of transformer planning, Power Equipment Division, Allis-Chalmers Manufacturing Company, Milwaukee, Wis. Mr. Clothier had been manager of the motor and generator department at the West Allis Works since 1956.

M. S. Coben (AM '47), former assistant sales manager for NJE Corporation, Kenilworth, N. J., has been appointed sales manager for Universal Transistor Products Corporation, Copiague, L. I., N. Y.

Nathan Cohn (AM '29, F '54), Philadelphia, Pa., vice-president of Leeds and Northrup Company, was named to the position of president-elect–secretary for 1961-62 of the Instrument Society of America. He is in line for the post of president of the society in 1962-63. Mr. Cohn has served as a member of the AIEE Feedback Control Systems Committee (1958-61).

S. A. Cory (M '58) has been appointed senior engineer in the Motor Division of Hydro-Aire Company, Burbank, Calif., a Division of Crane Company.

Frederic Cox (AM '41), for the last 5 years Metropolitan Edison Company's Western Division manager, York, Pa., has been elected a vice-president of the company.

D. A. Davis (M '48), manager of the Customer Services Division, Cannon Electric Company, Los Angeles, Calif., has been appointed assistant to the president of Avnet Electronics Corporation, Westbury, N. Y.

H. L. Durgin (M '40, F '54), formerly executive vice-president of the Central Vermont Public Service Corporation, Rutland, Vt., has been named president of the corporation. **W. M. Edson** (AM '54), who last January was appointed chief engineer and manager of operations, has become vice-president—operations and construction. **H. S. Lewis** (AM '36, M '52), formerly chief distribution engineer, has been promoted to chief engineer and placed in charge of the newly formed Division of Engineering and Planning.

C. J. Ellis (AM '47, M '60) has been elected regional vice-president of the General Electric Company for the South Eastern region.

Fabian Bachrach

H. L. Durgin

J. J. Fredrickson (AM '47, M '54) has been appointed secretary of the East Central District, AIEE, which includes 3,000 electrical engineers in Michigan and Ohio. An employee of the General Electric Company since 1944, Mr. Fredrickson is manager of Distribution Equipment Sales for the Michigan region of General Electric's electric utility sales operation.

George Friedl, Jr. (M '38), formerly vice-president and director of operations for the Westwood Division, Houston Fearless Corporation, Hawthorne, Calif. Prior to joining Houston Fearless, Mr. Friedl was vice-president and general manager of Litton Industries' Electronic Equipments Division.

W. L. Freienmuth (AM '48, M '56) has been appointed to the newly formed position of manager of the Research and Development Branch, Vitro Laboratories, Silver Spring, Md.

J. E. Fulenwider (AM '53) has been appointed supervisor of Electronic Switching Techniques with the Research Department of Automatic Electric Laboratories, Inc., Northlake, Ill., a subsidiary of the General Telephone and Electronics Corporation. He was formerly engaged in engineering consulting work for Booz-Allen Applied Research, Glenview, Ill., an affiliate of Booz-Allen and Hamilton, management consultants.

R. F. Gilkeson (AM '40, M '47), manager of the engineering and research department of the Philadelphia Electric Company, Philadelphia, Pa., since October 14, 1960, has been elected vice-president in charge of engineering and research.

L. H. Gillette (AM '55), who joined The Stanley Works, New Britain, Conn., in 1958, has become marketing manager, industrial hardware.

V. A. Giroux (AM '50, M '58) of Santa Monica, Calif., has been promoted to associate professor of Engineering of Los Angeles State College. He joined the college faculty in 1957.

A. N. Goldsmith (M '15, F '20, Member for Life), consulting engineer, has been elevated to honorary membership in the Society of Motion Picture and Television Engineers. Dr. Goldsmith is a former president of the society and has been a member for 33 years.

Paul Gottfried (AM '51, M '58), formerly a partner in Reliability Engineering Associates of Chicago, Ill., has joined Booz-Allen Applied Research, Inc., as a reliability scientist in the company's Washington, D. C., offices.

A. D. Gronner (AM '46, M '50) has been named vice-president in charge of engineering, and **M. L. Brailey** (AM '46), vice-president in charge of research and development, Spaceonics, Inc. Both Dr. Gronner and Dr. Brailey formerly were associated with the American Machine and Foundry Company. Dr. Gronner has served on the AIEE Feedback Control Systems Committee (1956-61).

Philadelphia Electric Company, Philadelphia, Pa., has announced the following appointments in its engineering and research department: **J. H. Harlow** (M '43, F '58), chief mechanical engineer since 1948, has been named chief engineer; **F. J. Berger** (AM '27, M '44), formerly assistant chief electrical engineer, has become chief mechanical engineer; and **F. W. Myers** (AM '26, M '52), who was engineer in charge of station design,

J. H. Harlow

has been assigned as assistant chief electrical engineer. In the department's electrical engineering division, assignments were made as follows: **Daniel Leitch, Jr.** (AM '52, M '58), previously engineer in charge of station equipment, was appointed engineer in charge of station design; **W. E. Scholz** (AM '41, M '45), engineer in charge of field engineering, was appointed engineer in charge of station equipment, and **T. C. Sickles** (AM '51), supervising engineer of electrical engineering, was named engineer in charge of field engineering. Mr. Myers has served on the AIEE Professional Conduct Committee (1960-61). Mr. Scholz has served as Sections Committee Liaison, District Technical Operations Department representative (1960-61).

G. W. Hart (AM '50) has been appointed vice-president, marketing of Electronic Energy Conversion Corporation, Bethpage, N. Y. Mr. Hart was formerly with the General Electric Company where he was manager of marketing administration and personnel development for the light military electronics department.

J. C. Hogan (AM '47, M '53), professor of electrical engineering at the University of Missouri, has been named acting dean of the University College of Engineering and acting director of the Engineering Experiment Station. Dr. Hogan has served on the AIEE Rotating Machinery Committee (1959-61).

L. C. Holmes (AM '31, F '51), director of engineering operations at Stromberg-Carlson, a division of General Dynamics Corporation, has been named to the Electrical Engineering Advisory Committee of the College of Engineering, University of Rochester. Mr. Holmes has served as AIEE vice-president (1958-60) and director (1961-65). He is a member of the following AIEE Committees: Recognition Awards (1959-63), Intersociety Relations (1959-62), Board of Directors (1958-65), Finance (1961-62), and Planning and Co-ordination (1961-62).

A. J. Hornfeck (AM '37, F '55) has been appointed director of research, Bailey Meter Company, Cleveland, Ohio. Mr. Hornfeck was appointed director of the research laboratory in 1953. **J. V. Werme** (AM '52) has been named manager of

L. I. Komives

the electrical engineering department. Mr. Werme came to Bailey Meter in 1956 as a research engineer. Both Mr. Hornfeck and Mr. Werme have served on the AIEE Recording and Controlling Instruments Committee, Mr. Hornfeck in 1956-61 and Mr. Werme in 1957-61.

Richard R. Hough (AM '41, M '58), operating vice-president of the Ohio Bell Telephone Company for the last 2 years, has been elected a vice-president of the American Telephone and Telegraph Company. Mr. Hough will be in charge of engineering for American Telephone and Telegraph.

F. M. Hull (AM '33, M '52), formerly assistant superintendent of the steam and conduit division of the Detroit Edison Company, Detroit, Mich., has been named assistant superintendent of the company's underground lines cable division. Mr. Hull has served on the following AIEE Committees: Insulated Conductors (1955-61, chairman 1959-61) and Power Division (1959-61).

Giannini Controls Corporation has announced the appointment of **R. D. Jablonsky** (AM '41) as manager of its Servo Component Division, Glendale, Calif. Mr. Jablonsky was formerly chief engineer of the Transducer Division.

R. R. Jenner (AM '39, M '48), vice-president of Mechanical Products, Inc., Jackson, Mich., has been named sales manager for the Abrams Instrument Corporation, Lansing, Mich., a subsidiary of the Curtiss-Wright Corporation.

L. I. Komives (AM '41, F '54), assistant general superintendent of the Detroit Edison Company's underground lines department and 1960 winner of the company's highest employee award, retired September 1, after 35 years of service. He started with Detroit Edison as a cable engineer in the company's electrical system department in 1926 and later rose through a series of supervisory posts in the underground lines department. Mr. Komives was named assistant general superintendent in 1953. He won the Detroit Edison's Alex Dow Award for his outstanding work in organizing an electrical industry group which was responsible for designing and constructing test-

Dr. R. C. Machler

ing facilities for extra-high-voltage underground cables.

Robert Kravetz (AM '47, M '54), formerly quality assurance requirements and specifications manager for the Lockheed Missile and Space Division, has been named sales manager of Dunn Engineering Corporation, Cambridge, Mass. Mr. Kravetz has served on the AIEE Computing Devices Committee (1956-61).

R. C. Machler (M '46, F '61) has retired as director of research and development, Leeds and Northrup Company, Philadelphia, Pa., after 28 years with the manufacturer. Dr. Machler will engage in consulting work with Leeds and Northrup as one of his clients. He is an authority in high-temperature measurements and is the inventor of the potentiometer type of optical pyrometer introduced in the middle 1930's. He holds 12 patents in this country and 6 in Great Britain, and has received a Naval Ordnance Development Award for work performed with the Office of Scientific Research and Development.

D. F. McNulty (AM '60) has been appointed application engineer in the control department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis. **E. M. Underwood** (AM '58) was named an assistant engineer in power systems engineering. Both Mr. McNulty and Mr. Underwood recently completed the Allis-

Chalmers training course for graduate engineers.

R. A. Niles (AM '49, M '60) has been promoted to chief distribution engineer of the Wisconsin Electric Power Company, Milwaukee, Wis. Mr. Niles joined the company in 1948 as a junior engineer. He is being succeeded as assistant to the manager of electrical operations by **K. E. Wolters** (AM '51, M '60), formerly assistant superintendent of the electrical testing and meter division.

Gabriel Novick (AM '49), formerly senior engineer at Westinghouse Electric Company, Baltimore, Md., has joined Tucor, Inc., a subsidiary of Trak Electronics Company, Wilton, Conn.

A. C. Omberg (M '58), who has been an assistant group executive of the Bendix Corporation, South Bend, Ind., has been named a group executive.

W. L. Peterson (AM '38, M '46) has been appointed manager of the motor and generator department, Allis-Chalmers Manufacturing Company's Industrial Equipment Division, Milwaukee, Wis. Mr. Peterson was formerly assistant manager of the motor and generator department.

Sigma Instruments, Inc., South Braintree, Mass., has appointed **R. H. Pierce** (AM '55), vice-president, engineering, and **Philip Garnick** (AM '52), vice-president, sales.

Stanley Plaisance (AM '52) has been named vice-president of engineering of INVAC Corporation, Natick, Mass. He joined INVAC in 1960 as chief engineer.

W. J. Plate (AM '51), manager of the Cable Accessories Division of the Anaconda Wire and Cable Company, has been promoted to the newly created position of manager, rubber and plastic specification products, in Marion, Ind.

G. F. Quittner (AM '57) has been appointed chief research engineer of Assembly Products, Inc., Chesterland, Ohio. Mr. Quittner joined Assembly Products in 1960.

L. E. Saline (AM '47, M '54) has been appointed manager of the Specialty Devices Operation of the General Electric Company's defense systems department. Dr. Saline was formerly manager of the defense systems department's Information Systems Section, Bethesda, Md. He has served on the AIEE Computing Devices Committee (1959-61).

E. N. Schalk (AM '55) has become manager of application engineering, Electrical Products Division, Fostoria Corporation, Fostoria, Ohio.

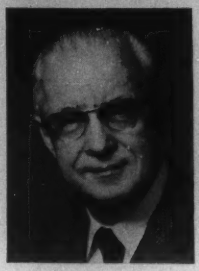
C. T. Shoch (M '48) retired as director of information services of the Pennsylvania Power and Light Company, Allentown, Pa., on October 1, after more than 37 years of service with the utility. Mr. Shoch began his long and varied career with the company in 1924 as a repairman at the Harwood power plant. He became a field engineer in 1926 and subsequently test engineer, plant betterment engineer, and boiler room engineer. In 1935, he was appointed an industrial sales representative in the company's commercial department. As a specialist in industrial power applications, he held the positions of industrial engineer, system sales representative, industrial and commercial sales manager, and assistant to the vice-president, commercial. In 1954, Mr. Shoch was named co-ordinator of the company's customer relations activities. He became director of information services 2 years ago.

M. G. Spooner (AM '49) has been named assistant to the head of the computer research department, Cornell Aeronautical Laboratory, Buffalo, N. Y.

A. Y. Taylor (AM '37, M '40) of Marblehead, Mass., has been elected executive vice-president, Jackson and Moreland, Inc., consulting engineers of Boston, Mass. Mr. Taylor had been vice-president for testing and laboratory facilities, Nuclear and Industrial Engineering Projects, Jackson and Moreland. Mr. Taylor has served on the following AIEE Committees: Nucleonics (1956-61, chairman 1960-61), Science and Electronics Division (1960-61), and Nuclear Congress and Nucleonics (1960-61).

S. L. Walworth (AM '26, M '45, Member for Life), district manager for Ohio Brass Company in western Pennsylvania, will retire January 1. Appointed to succeed him is **Kenneth Benson** (AM '51), the company's mining division representative in the territory for 10 years. Mr. Benson will continue to operate out of the company's Pittsburgh, Pa., office. Mr. Walworth has handled the company's electric power accounts for 34 years.

R. A. Webb (Affil '52) has been appointed manager of utility sales, Phelps Dodge Copper Products Corporation, New York, N. Y. Since 1952, Mr. Webb was a power cable sales engineer in charge of all utility sales engineering for high-voltage cable.



W. S. Wilder

Dion Weiss (AM '40, M '53) has been appointed chief electrical engineer for the Jersey Central–New Jersey Power and Light Companies, Morristown, N. J. Mr. Weiss, who was formerly assistant chief engineer for the electric utilities, succeeds **C. A. Dougherty** (M '57), who retired recently.

Gerald Weiss (AM '44, M '56), assistant professor of electrical engineering at Polytechnic Institute of Brooklyn, has been awarded the CompuDyne Foundation in Industry Scholarship. Selection of Dr. Weiss was made by the Foundation for Instrumentation, Education and Research, Inc. In addition to receiving the $1,000 award, Dr. Weiss spent a 4-week period at CompuDyne Corporation in Hatboro, Pa., where he studied the application of the most recent theory in instrumentation and automatic control.

W. B. Wells, Jr. (AM '51), for the last 9 years an industrial salesman in the Pittsburgh, Pa., branch office of the Minneapolis-Honeywell Regulator Company, has been named branch sales manager at Dayton, Ohio.

W. S. Wilder (M '49, F '60) retired on August 31 as manager of electrical engineering at the Wisconsin Electric Power Company after more than 42 years of service. Among his assignments were special projects in radio and telephone communications systems. He performed the basic research and design for the company's first 250-mile, 138-kv transmission system. Later, he was responsible for the introduction of a supplementary 230-kv transmission system with associated power plant and substation equipment to co-ordinate these two high-voltage transmission systems. **C. S. McNeer** (AM '56) will succeed Mr. Wilder as manager of electrical engineering at the company. Mr. McNeer joined the company in 1950.

OBITUARIES

Louis Denton Bliss (AM '00, M '17, F '20, Member for Life), who founded the Bliss Electrical School in Takoma Park, Washington, D. C., in 1893 and directed its program for 56 years, died recently. Mr. Bliss was born July 31, 1871, in Newburgh, N. Y. During World War I, he prepared a course for the intensive training of soldiers for electrical work in the U. S. Army. The Bliss School gave a special course in radio and radar work during World War II to U. S. Navy enlisted men under Mr. Bliss' direction.

Edward James Burger (M '42, F '50), retired manager of the Lake Erie Division of the Ohio Edison Company, Lorain, Ohio, died recently. Mr. Burger was born July 27, 1892, in Las Vegas, N. Mex. He was graduated from the University of Missouri in 1916 with an elec-

trical engineering degree. Mr. Burger was associated with the Ohio Public Service Company in Lorain for 18 years as a vice-president and division manager. He was also employed by Ohio Public Service in Warren, Ohio, before he became a division manager of Ohio Edison when the two companies were merged; he retired 4 years ago. During 1947, he served as a consultant to the Secretary of War on a mission of four engineers to Japan, whose purpose it was to determine the electric steam generating capacity that might be removed from Japan for reparation purposes without reducing the Japanese economy below that specified in the Potsdam Agreement. Mr. Burger was a member of the Advisory Board to Gen. Douglas MacArthur in 1948-49, assigned to review the proposed reorganization plans being imposed on some 325 large Japanese companies in all industrial categories. He also acted as power consultant to the Supreme Commander on Japanese and Korean Power Problems. Mr. Burger took part in three global strategy conferences at the United States Naval War College in Newport, R. I., and served as a civilian consultant to the United States Naval Reserve in Lorain.

Nathaniel Allen Carle (AM '06, M '10, F '13, Member for Life), cost analyst, Drake-Puget Sound, Seattle, Wash., died recently. Mr. Carle was born May 28, 1875, in Portland, Ore. In 1898, he graduated from Stanford University with an A.B. degree in mechanical engineering. During 1900-09, he was employed as an engineer with Westinghouse, Church, Kerr and Company, New York City. He became an engineer for the Puget Sound Bridge and Dredging Company, Seattle, Wash., in 1909, and chief engineer, Public Service Electric Company, Newark, N.J., in 1912. Mr. Carle was at one time city engineer of Seattle, Wash. He served on the following AIEE Committees: Coordination of Institute Activities (1920-21), Executive (1916-20), Finance (1916-20, chairman 1917-20), Headquarters (1917-20, chairman 1917-20), Power Stations (1918-19), Publication (1919-21, chairman 1920-21), Public Policy (1917-21), Standards (1915-19), Transmission and Distribution (1915-16), American Commission on Electrolysis (1920-32), American Engineering Standards (1916-19), Engineering Council (1917-20), Electrical Machinery (1922-24), and the Edison Medal (1924-29).

Harry Alyn Cramer, Jr. (M '47), design specialist, The Martin Company, Orlando, Fla., died August 9. Mr. Cramer was born June 1, 1910, in Wilmington, Del. He received a B.S. degree in electrical engineering in 1932 from the Drexel Institute of Technology. Mr. Cramer started with The Martin Company in 1936 as an engineering draftsman, and became head of the Electrical Engineering Laboratory in 1947. He subsequently was moved to the position of electrical group engineer in advanced design, and later was assigned to the Convair for Nuclear Effects Study. In 1958, he started at Cape Canaveral and, in August 1959, transferred to Orlando as design specialist.

James Dixon (AM '02, M '13, Member for Life), retired electrical engineer, Myrtle Beach, S. C., died on September 26. Mr. Dixon was born March 5, 1877, in New York City. He graduated from Columbia University in 1901 with an electrical engineering degree. After graduation, he was employed for 5 years by the Gray National Telautograph Company, New York City, as an electrical engineer. Mr. Dixon was also associated with the Reliance Electric and Engineering Company, Cleveland, Ohio, and the Crocker-Wheeler Company, Ampere, N.J. He served on the AIEE Industrial and Domestic Power Committee (1916-20) and Application to Iron and Steel Production Committee (1936-38).

Cyril Paul Feldhausen (M '40), a supervising engineer at Cutler-Hammer, Inc., Milwaukee, Wis., since 1930, died September 16. He was born January 2, 1904, in Green Bay, Wis. Mr. Feldhausen joined the firm in 1928, shortly after his graduation from the University of Wisconsin where he earned a B.S. degree in electrical engineering. He attended the company's student training course during 1928-29, was assigned to the Research Laboratory of the experimental department in 1929-31, and became a member of the engineering department in 1931. Mr. Feldhausen was in charge of Cutler-Hammer's printing equipment control for more than 20 years and held 15 patents relative to printing press drives and control. His technical writings included a section on motor control in the *Standard Handbook for Electrical Engineers* and mechanical bulletins on printing press drives for the American Newspaper Publishers Association. Mr. Feldhausen was a member of Eta Kappa Nu and Tau Beta Pi.

Miles Edwin Van Sickle (AM '48, M '50), assistant chief local system operator, Pennsylvania Power and Light Company, Harrisburg, Pa., died July 11. Mr. Van Sickle was born June 29, 1900, in Jamison City, Pa. He studied electrical engineering at the Carnegie Institute of Technology and, in 1923, started with the Pennsylvania Power and Light Company in Williamsport, Pa., as a steam electric station operator. He was successively advanced to assistant superintendent of distribution, Williamsport Division, and system operator, in Williamsport and in Hazleton. Mr. Van Sickle became assistant chief local system operator in Harrisburg in 1946. He was a member of the Society of American Military Engineers. Mr. Van Sickle was chairman of the Susquehanna Section, AIEE, for 1960-61 and Section vice-chairman for 1959-60.

Archibald Frederick Wilson (AM '23, M '32, Member for Life), retired officer of the Ohio Bell Telephone Company, Cleveland, Ohio, died August 17. At the time of his retirement in 1950, he was an assistant vice-president of the company. Mr. Wilson was born September 15, 1885, in Toronto, Canada. He graduated from Toronto University with the bachelor's degree in electrical engineering. Mr. Wilson was an equipment and maintenance superintendent for the Cleveland Exchange of Ohio Bell Telephone during 1919-21. He subsequently became supervisor of plant operations in Ohio, plant superintendent of the Youngstown District, superintendent of dial conversions and Division Plant superintendent, chief engineer, and general plant manager.

SUMMARIES OF AIEE PAPERS

Each month, Electrical Engineering *publishes authors' 75-word summaries of all serially numbered papers sold at General and District Meetings. Preprints of these papers may be purchased at 50¢ each to members, $1.00 to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to : AIEE Order Department, 345 E. 47 St., New York 17, N. Y.*

Communication

61-1020 (I) — **A Buffer Store for Data Transmission.** *W. E. Baker, F. E. Froehlich* — A method is presented for connecting an information source emitting data at an arbitrarily fluctuating rate to a synchronous transmission system. Expressions are derived relating the fluctuating input data rate and the maximum transmission efficiency to the capacity of a buffer store necessary to establish this connection. An acoustic delay line buffer store whose input and output are independent of each other is described. The buffer store has a capacity of 45 bits; operates with 2-μsec spacing between pulses, and employs a unique method of generating a 500-kc timing signal.

61-1023 (I) — **Computer Simulation of the Use of Group Codes with Retransmission on a Gilbert Burst Channel.** *W. R. Cowell, H. O. Burton* — A study of error control by coding was made by Monte-Carlo simulation of a burst-noise channel on an IBM 7090. Using short group codes, comparisons were made between correction and detection with retransmission. Also, the effect of interleaving the code words was studied.

Error detection with retransmission showed a consistently better performance than error correction and the time division resulting from interleaving was effective in combating burst-type error patterns.

CP61-1039 — **Economics of Exchange Lines Concentrators.** *J. R. Kershaw* — Exchange lines concentrators are economic solutions to outside telephone plant distribution facility relief problems when certain circumstances prevail. Derived charts indicate by observation when conditions warrant consideration of concentrator usage. Concentrators can be used as either temporary or permanent parts of plant with economics serving as the criterion. In any situation, concentrators must be loaded to the designed call-carrying capacity to effect the engineered savings.

CP61-1040 — **Traffic Considerations in the Use of Exchange Line Concentrators.** *W. J. Blyth* — Traffic administration must co-operate closely with the other departments to assure that assignment of customers within a concentrator is done in such a manner that service provided by the concentrator is just as good as it would be if the customer were connected directly to the central office.

CP61-1041 — **The New Line Concentrator 1A.** *W. Whitney* — A description is given of the new Line Concentrator no. 1A, covering the features, the new magnetically latching crossbar switches and relays, the switching networks, and the method of operation. This equipment will serve 50 or 100 lines over 10 or 20 trunks, respectively, with two control pairs in either case, and can be used in almost any type of central office. The working limits, field of use, administration, maintenance, and economics are discussed.

61-1063 (I) — **A 1,650-Bit-per-Second Data System for Use over the Switched Telephone Network.** *S. Brand, C. W. Carter* — The engineering of a data system for use on the switched message network is reviewed. First, it is shown how the conditions imposed by this specific application influenced the selection of signal characteristics. As part of this discussion selection of raised-cosine pulse shaping is supported by a brief treatment of some fundamentals of pulse transmission. Finally, the results of a field trial are summarized to show that, while the system objectives were met, factors such as delay distortion, attenuation distortion, and transmission loss limited the performance obtained.

61-1065 (I) — **Two Measuring Techniques for the Investigation of Impulse Noise and Dropouts on Phone Lines.** *J. Kelly, J. Mercurio, D. Willard* — Two methods of measuring impulse noise on telephone lines are set forth in this paper. One of these methods also records the occurrence and duration of dropouts. The latter method provides a means of identifying the cause of errors during the transmission of digital data. Results of a statistical analysis of impulse noise and dropouts on a data circuit between Boston and Chicago are presented.

61-1069 (I) — **A Tone Disabler for Bell System 1A Echo Suppressors.** *L. F. Bugbee, Jr.* — The capability of simultaneous 2-way transmission over the direct-distance dialing (DDD) network will allow data system to provide more efficient error detection and correction, system control, and circuit assurance schemes. This capability is made available by the development of a tone disabler, which will inhibit the suppression function of any echo suppressors in the connection upon command of a conditioning tone, and allow normal operation on voice transmission. This paper describes the engineering design and operational features of the tone disabler.

61-1072 (I) — **The Level Tracer, an Instrument for Time Saving and Better Measurement in the Speech Band.** *Martin Niedereder, Benjamin T. Sanders, Jr.* — The development and construction of a visual voice frequency transmission measuring set is described and a short summary of its applications is included. The instrument provides for the display of measurements of level, impedance, return loss, impedance comparison, and level comparison on the face of a cathode-ray tube as a function of frequency. The values in db or ohms are read directly from a calibrated graticle. The instrument described is the latest of a series whose initial development was begun in 1941.

CP61-1080 — **Videograph Communications Equipment.** *J. J. Stone, Jr.* — Equipment is described for scanning, transmitting, and reproducing documents over wide-band, video communications systems. The printer uses an electrostatic printing tube to image dielectrically coated paper, which may then be developed and fixed by conventional techniques. The scanner employs a mechanical optical system to produce the video signal representing the original document. Operating speeds are limited by the video band pass of the communications system and are presently capable of transmitting 8½-inch-wide by up to 17-inch-long documents in 6 seconds.

CP61-1086 — **Experience and Results Observed with DDD Transmission Design in Interconnection with the DDD Network.** *D. H. Potter* — Engineering design of terminal trunks for direct-distance dialing (DDD) interconnection must include installation, operation and maintenance considerations. DDD operation revises existing concepts of transmission trouble detection, and analysis of operational and maintenance experience is mandatory for economical and effective operation. With engineering technology providing increasingly complex plant, the major problem confronting the industry today is the education and training of company operating personnel with the importance of transmission in DDD terminal trunk operation.

CP61-1101 — **Deviation Equalizer for N Carrier Lines.** *M. Aruck* — An adjustable deviation equalizer employs four mutually independent equalizing shapes, each adjusted by a single control to reduce transmission deviations on the longer N carrier telephone lines. Mathematical analysis of typical N carrier line characteristics shows that such an equalizer could effectively reduce these distortions. Human factors tests show that an equalizer of this type is easier and quicker to adjust than an alternate resonant shunt-type unit.

CP61-1109 — **Traffic-Handling Possibilities with a Progressive Marking, Self-Pathfinding Solid-State Crosspoint Network.** *I. Draayer, A. Wachowski* — In a previous paper, a new progressive marking, self-pathfinding technique for establishing a connection through solid-state crosspoint networks was described. The following paper deals with the traffic-handling capacity of a switching network using one of the variations of this technique. Some approximate formulas will be given for the calculation of the probability of congestion, as well as the time necessary to build up a connection. Conditions are derived for a minimum of crosspoint elements per subscriber.

61-1113 (I) — **Santa Barbara County 6,000-Mc Microwave System.** *R. K. Lentz* — Important considerations when designing a microwave system are power output from the transmitter, the antenna size, the distance from a terminal to the repeater, the path obstruction clearance, and the value of noise that will be permissible. The heart of this entire system lies in the method of interconnecting the radio equipment at the repeater site. The interconnection was accomplished by back-to-back hybrid transformers rather than costly drop insert equipment.

Industry

CP61-1047 — **How to Select Overcurrent Relay Characteristics.** *D. V. Fawcett* — A table lists induction overcurrent relays available from the various manufacturers with their equivalent time vs. current characteristics. Another table lists relay types and current ranges suitable for phase and ground protection of twelve of the most commonly encountered industrial plant distribution and motor circuits. These recommendations are listed as a result of detailed considerations of a hypothetical industrial power system. Use of these tables will result in good relay co-ordination and protection in the majority of applications when time does not permit a detailed study.

Power

61-1024 (III) — **Magnetic Field of a Rectangular Commutating Pole.** *A. E. Dvoracek* — Mathematical investigation of flux density on armature surface is described. The actual profile of the space between stator and rotor has been simplified assuming rectangular compole, straight armature surface, and straight main pole side. The mmf of compole coil is assumed as caused by a thick

current layer with constant linear current density, extended between two arbitrary points on compole sides. The distribution of armature mmf is assumed arbitrary over the commutating zone and uniform outside it.

61-1043 (III) — **Surge Impedance and its Application to the Lightning Stroke.** *C. F. Wagner, A. R. Hileman* — Corona effects and a temporary high resistance introduced into the path of the return stroke current are two factors that contribute to the determination of the velocity of the propagation and surge impedance of the return stroke. Using field theory concepts, it is estimated that the surge impedance of the stroke is about 3,000 ohms. This quantity is of value in estimating the length of the last step and the wavefront of the stroke current.

CP61-1044 — **Installation of Machine Drilled Caisson Footings in Noncohesive Soils.** *J. C. Engimann, W. J. Fern* — Two methods have been developed for installing machine-drilled caisson tower footings in wet noncohesive soils which are generally unsuitable for normal caisson installations. Specific examples illustrate the installation techniques and equipment requirements for each method. In many cases, footings installed by these methods are less expensive and more quickly installed than other types used in such adverse soil conditions.

CP61-1054 — **The Load Flow Problem — Its Formulation and Solution — Part I.** *A. H. El-Abiad, Marjorie Watson, G. W. Stagg* — The load flow problem is formulated by a system of algebraic nonlinear equations using the node-pair frame of reference. Solutions are determined by three methods: (1) Gauss-Seidel (using bus admittance matrix), (2) Relaxation (using bus admittance matrix), and (3) Gauss-Seidel (using bus impedance matrix). Comparative results are obtained from the application of these methods to actual transmission systems. A brief summary of previous work on this problem is included and points of interest for further research noted.

61-1055 (III) — **Hydro-Thermal Economic Scheduling. Part IV, A Continuous Procedure for Maximizing the Weighted Output of a Hydroelectric Generating Station.** *B. Bernholtz, L. J. Graham* — The derivative of the function relating maximum station output to station discharge is discontinuous at certain points. The attendant difficulties in maximizing weighted hydro output were avoided in Part I by using a maximizing procedure based on tabulated values of output and discharge. Here an alternative procedure is presented. Maximum station output is approximated by a concave differentiable function of discharge. In maximizing weighted hydro output, the derivative plays an essential role and and physically possible discharge is permitted.

CP61-1056 — **Input and Output Techniques for an On-Line Digital Computer.** *W. G. Beyer, W. B. Schultz, T. W. Hissey* — Digital computer control systems for use in on-line computing and control in the power, process, or heavy industries must be specifically designed for continuous, reliable, minimum down-time operation. Each phase of the system — input-output equipment, digital computer, and associated automatic control loops — must satisfy the specific design aim of continuous operation with maximum reliability. This paper outlines some of the philosophies and techniques used in the provision of the input-output equipment required to meet these design goals on a particular digital computer control system.

CP61-1062 — **Bibliography on Wood Pole Transmission Lines.** *M. Darveniza, W. Wager*—Literature available in this field has accumulated as a result of over 40 years' experience with wood pole transmission lines. In 1954, a long-term research project entitled "Impulse Strength of Australian Timber" was initiated by the Electrical Research Board of the Electricity Supply Association of Australia. This paper summarizes the results of a survey of available literature on the subject of wood pole transmission lines carried out in connection with this project.

CP61-1090 — **Conductor Vibration — A Study of Field Experience.** *C. B. Rawlins, K. R. Greathouse, R. E. Larson* — Plots are constructed, based upon design data from numerous existing overhead lines, in terms of variables, intended to reflect the tendency of the lines towards aeolian vibration damage. Lines actually damaged are indicated. In the plots for lines protected by armor rods or by Stockbridge dampers, the points for damaged lines fall for the most part in a different region from those for undamaged lines. The plots are intended as guides for selecting vibration protection for new lines.

CP61-1092 — **Fuel Cells and Utilities.** *J. D. Flynn* — Fuel cell effects on utilities will vary with their economic size. They will become practical initially in watt sizes, then in kilowatt and finally in megawatt sizes. As their development advances into the kilowatt range they will stimulate brisk competition among the oil industry, gas utilities, and electric utilities for the opportunity of being the "single-energy" source. When the megawatt size is reached they will tend to favor electric utilities over other energy suppliers.

CP61-1100 — **Guyed Mast High-Voltage Transmission Structures.** *H. B. White* — In North America and most other parts of the world, rigid-type towers have found most favor for high-voltage transmission of electric power. In a few countries, guyed mast towers have been used for more than 30 years and their use is now spreading. Since 1959, at least eight guyed mast high-voltage transmission lines of various designs have been or are being erected in North America. This paper reviews briefly guyed tower development, describes types now in use, and points up factors that must be considered.

CP61-1102 — **Transmission Lines on Restricted Rights of Way.** *A. H. Anderson, M. Markowsky* — A questionnaire concerning the design and construction of transmission lines on restricted rights of way was prepared and sent to 34 major utilities to obtain their practices and experiences in resolving the various problems in this area. Answers were obtained from 28 utilities and are summarized in this paper.

CP61-1104 — **Basic Parameters in Determining the Insulation Requirements of Transmission Lines.** *J. M. Clayton* — This paper presents the insulation requirements of transmission lines from 69 to 500 kv, based on 60-cycle voltages, switching surges, and lightning surges applied to the line insulation under normal operating and transient conditions. Factors such as contamination which affect performance of insulation are considered. For lines designed to be relatively free from lightning flashovers, minimum insulation requirements are determined by lightning considerations through 345 kv. For 500-kv lines, minimum requirements are determined by switching surges.

CP61-1106 — **Reconductoring Transmission Lines.** *J. R. Steiner* — During the past two decades, typical solutions to the ever present problem of providing utilities with increased transmission capacity have been new lines, increased voltages and current ratings, bundling, and reconductoring of existing lines. A brief review of these alternatives provides background for an analysis of the reconductoring solution, a practical method to prolong economically the useful life of a transmission line, if changes in design philosophy are acceptable.

CP61-1107 — **Industrial Control Application in Steam Electric Generating Stations.** *M. P. Smull* — Practices followed in the application of low-voltage switchgear, contactors, and molded case breakers in generating stations are discussed. These practices are designed to obtain equipment offering (1) maximum safety to personnel, (2) maximum reliability consistent with economy, and (3) convenience of maintenance. The modifications to obtain the desired characteristics include such features as additional barriers in switchgear, use of oversize contactors, and heavy-duty equipment in all cases where possible. Broad use of air circuit breakers is featured.

CP61-1110 — **Formette Testing of Armature Coil Insulation for Large D-C Machines.** *J. S. David, G. C. McClary* — Test data from two d-c armature coil formettes are reviewed for the purpose of determining where AIEE Proposed Test Procedure no. 511 can be altered to meet the specific needs of coils for large d-c machines. Recommendations are made concerning the Test Procedure and the design of the formette itself.

CP61-1111 — **Effects of a Large Copper-Melting Arc Furnace on an Electric Utility System.** *C. S. Crow, W. Saller,*

F. D. Shaw — Voltage dip tests on an 800-kva copper-melting arc furnace verify that its effects on the electric supply system are less severe than were anticipated from calculations because of its sensitive, high-speed, hydraulic electrode positioning system for the control of the arc furnace power input. Large arc furnaces melting copper have generally been unstable and disturbing to utilities systems.

Science and Electronics

61-1078 (I) — **Electrical and Pressure Losses in a Magnetohydrodynamic Channel Due to End Current Loops.** *G. W. Sutton, H. Hurwitz, Jr., H. Poritsky* — Electrical and pressure losses are calculated for d-c magnetohydrodynamic (MHD) power generators, accelerators, or induction pumps with a rectangular parallelepiped geometry with electric field, magnetic field, and fluid flow mutually perpendicular. For an MHD generator with a cubic geometry, the maximum conversion efficiency of only 29 per cent can be improved to 90 per cent by increasing the length of the generator, inserting vanes, and extending the magnetic field.

61-1053 (I) — **Automatic Plotting of Characteristic Curves and Analog Solution of Algebraic Equations.** *D. M. Mitrovic* — For the characteristic equation $a_n s^n + a_{n-1} s^{n-1} + \ldots + a_2 s^2 + \xi S + \eta = O$ the relations between the coefficients ξ and η and the values $\zeta\omega$ and ω^{n2} are derived. The computer based on these relations may be used for plotting of characteristic curves used in the graphical analysis and synthesis of linear feedback control systems, for determination of roots of algebraic equations with real coefficients and for plotting of root locus for an arbitrary parameter.

61-1076 (I) — **Definitions for Semiconductor Rectifier Components.** *AIEE Rectifier Device Group of the AIEE Semiconductor Rectifier Committee* — Definitions covering physical structure, electrical characteristics, and ratings are given for semiconductor rectifier components. These definitions were prepared by the AIEE Rectifier Device Group and have been approved by AIEE and ASA. The definitions will be published as an AIEE Standard Publication No. 59A.

CP61-1089 — **Proposed Test Standards for Semiconductor Rectifier Cells, Rectifier Diodes and Rectifier Stacks.** *AIEE Rectifier Device Test Group of the AIEE Semiconductor Rectifier Committee* — The status of the preparation of standards for semiconductor rectifier components is reviewed. The contents of the "Proposed Test Standards for Semiconductor Rectifier Cells, Rectifier Diodes and Rectifier Stacks" are discussed briefly along with a request for industry comments. The proposed test standard prepared by the AIEE Device Test Group of the AIEE Semiconductor Rectifier Committee is presented, describing test procedures and test circuits of all types used in the rating, evaluation, inspection, and application of semiconductor rectifier components.

Conference Papers Open for Discussion

Conference papers listed below have been accepted by AIEE *Transactions* and are now open for written discussion until November 27. Duplicate double-spaced typewritten copies of each discussion should be sent to E. C. Day, Assistant Secretary for Technical Papers, AIEE, 345 E. 47 St., New York 17, N. Y., on or before November 27.

60-1201 **Optimized Transmission Tower Spotting on Digital Computer.** *V. Converti, E. J. Hyland, D. E. Tickle*

61-221 **Transient Torques in 3-Phase Induction Motors During Switching Operations.** *M. R. Chidambara, S. Ganapathy*

61-771 **Electrical Features of the Elk River Reactor Plant.** *D. C. McClintock*

61-785 **Experience with Line Dropping Up to 500 Kv at Hydro Quebec.** *L. Cahill, P. A. Baltensperger*

61-798 **Improving Transient Stability by Use of Dynamic Braking—I.** *W. H. Croft, R. H. Hartley*

61-813 **The Electrical Properties of Single-Layer Aluminum Conductors, Steel Reinforced (ACSR), Having Single Steel-Core Wires with Heavy Aluminum Coating.** *C. H. Jensen, R. E. DeMuth, R. W. Mowery*

61-971 **Dynamic Behavior of a 220-Kv Dead-End Suspension Bus During Short Circuit.** *A. W. Atwood, Jr., M. H. Mills, D. I. Downs, H. M. Stone*

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PLAN TO ATTEND THE

ELECTRICAL ENGINEERING EXPOSITION

HELD IN CONJUNCTION WITH

AIEE WINTER GENERAL MEETING

NEW YORK COLISEUM JANUARY 29-FEBRUARY 2, 1962

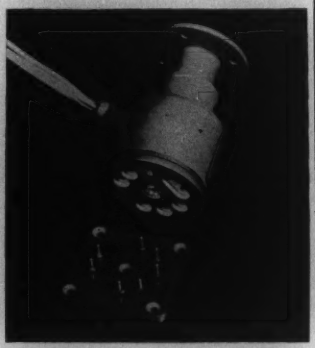
NEW/IMPROVED PRODUCTS

(Continued from page 8A)

direct voltage of 5 kv are possible with a new line of eight standard Transductors. The units are used to control and monitor the fields and armatures of motors to 100 amperes. Shunt-type current units are complementary to installed 50 mv or 100 mv standard shunts for measurement of currents to 20,000 amperes. Bus-tap current Transductors are connected directly to bus bars carrying from 20,000 to 200,000 amperes d-c. Proportional output is linear within accuracies of ±½ per cent at full scale. Supply voltage is 115 volts, 50 or 60 cycles. Rated load resistance is 9,000 ohms. *Norbatrol Electronics Corp., 356 Collins Ave., Pittsburgh 6, Pa.*

Electrical Coupling Device . . .

Complete environmental protection is a feature of a new quick-connect/disconnect coupling designed to operate with only 0.70-pound force for removal of the pins forming the connections. Connection



can be made even with an angular misalignment of 5 degrees between the two surfaces of the coupling. Model P/N 200 73004 is rated at 45 amp and meets electrical and vibration requirements of MIL-C-5015. Other models are available with characteristics and configurations to suit a large variety of special customer requirements. *Kellett Aircraft Corp., Willow Grove, Pa.*

Motor Drive . . .

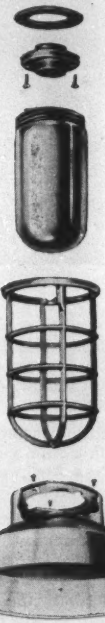
Available in 20, 25, 30, and 40 horsepower ratings, a new 6-speed Selectro-Shift drive has been introduced. Hydraulic clutches activated by electric solenoids shift the drive to any of six speeds while running under full load. Shifting is controlled by an electric push-button station which can be installed any required distance from the drive. The unit can be operated in either reverse or forward position in all six speeds. *Lima Electric Motor Co., Inc., Lima, Ohio.*

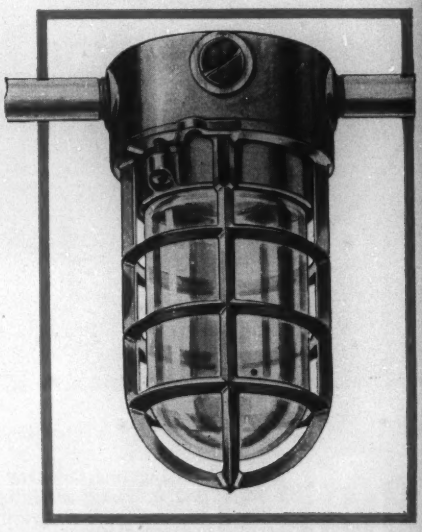
Quickly installed...a snap to service!

VAPOR* TIGHT

100 WATT FIXTURE

Combination junction box has 4 holes and 3 plugs as standard.





***UL-listed-fixtures enclosed and gasketed.**

Adalet VT fixtures give you the ruggedness and corrosion resistance of cast aluminum construction.

Installation — is easier with Adalet multiple tapped 4-way hub boxes.

Service — is a snap with the no-thread "twist-lift" bayonet-lock guard.

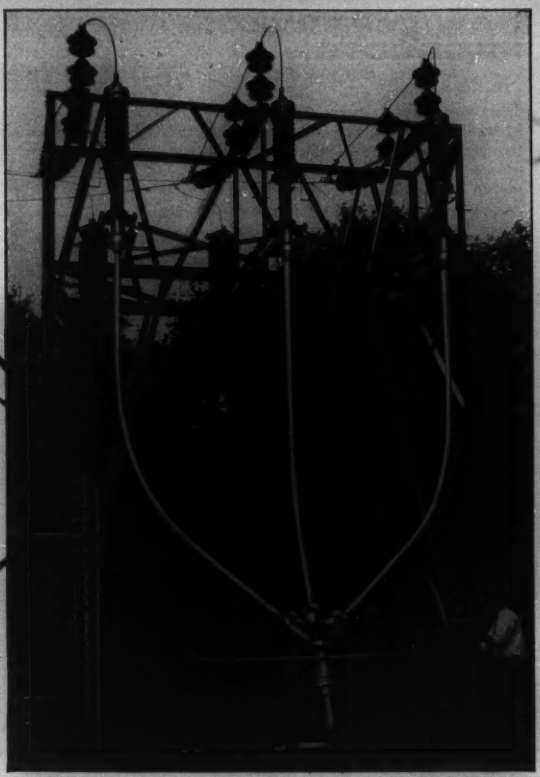
Globes — A choice of 7 colors in standard glass; 3 in heat resisting. Available for wall, pendant and outlet box mounting; 100 to 500 watt sizes.

Adalet

MANUFACTURING COMPANY
14300 Lorain Avenue
Cleveland 11, Ohio

Request Vapor-Tight Bulletin E 360

LILCO
completes first 69-kv self-contained aluminum cable installation



Long Island Lighting Company has recently completed installation of a 69-kv, high-pressure gas self-contained, aluminum-sheath cable underground and aerial through a suburban customer residential area. Results have been excellent. Part of a 75-mva loop, the installation has been found practical and economical.

Appearance of the aerial cable is trim, indicating that there is now available a means of transmitting bulk power more acceptable to the public than open-wire construction. Cost is estimated at approximately half that of underground pipe-type cable of similar capacity.

G&W has supplied a unique termination for this cable installation. The three-conductor, high-strength, aluminum-sheathed, 800-mcm cable is led at an angle into an aluminum spreader head. Aluminum tubing carries the individual conductors to separate G&W type ATA-N single-conductor potheads. Mechanical seals on both the spreader head and potheads permit the entire termination to operate at full cable gas pressure. G&W also supplied the gas-control cabinet that maintains pressure between 180 and 235 psi on the whole system.

G&W is a *specialty* company that welcomes unusual cable-termination and joint problems. By concentrating on cable accessories, G&W is able to devote research time toward development of termination characteristics for even the most advanced applications. Your special needs are our business—consult us, or your G&W representative.

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Canadian Mfr. • Powerlite Devices, Ltd. • Toronto, Montreal & Vancouver

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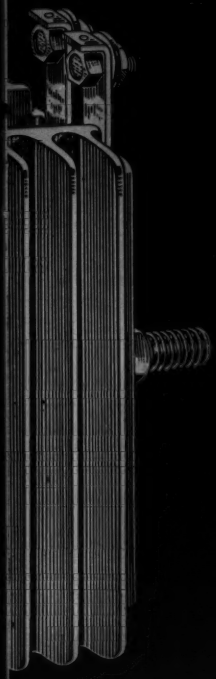
A61-3



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WHERE TO USE THE POWER POINT

- on clutches, computers, for cathodic protection
- business machines, and burglar alarms, and battery chargers
- on magnetic chucks and amplifiers and magnetic reactors
- on motors and brakes and to close circuit breakers
- in circuits with telephones, telegraph and other equipment, such as
- vibrators and relays and traffic control
- power supplies for autos and airplanes and electro-plating
- *in short: almost anywhere you need d-c power close to the Point of use*

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certified SEMICONDUCTORS

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All Syntron semiconductors have been tested and inspected to AQL level of 1.0, Inspection Level II, and are so certified. Electrical and mechanical tests include:

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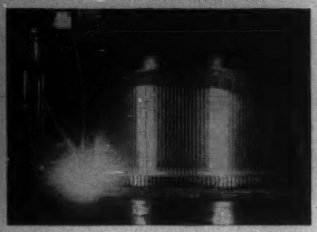
INDUSTRIAL NOTES

Tungsten Inert Gas Welding Helps Rebuild Traction Motors

Railroads should realize more miles per maintenance dollar, according to General Electric Co., through use of tungsten inert gas welding. The process is used



for making the connection between the armature coil lead and commutator riser in rebuilt traction motors for diesel-electric locomotives. The technique results in an all-copper joint, providing better protection against high-temperature damage, according to General Electric. Tungsten is used for the electrode and an inert gas is used to shield the molten weld puddle from atmospheric contamination.

New Generating Station Opened by Baltimore Gas and Electric

The new Charles P. Crane Steam-Electric Generating Station located on a 164-acre tract on the west shore of the Chesapeake Bay between Seneca and Saltpeter Creeks in Baltimore County has been formally dedicated by Baltimore Gas and Electric Co. The first 191,000-kw unit was recently placed in commercial operation and a second unit of similar size at the same site is under construction. The new plant cost $37,700,000, including the cost of the site and facilities installed on the site with the first unit. About $2,000,000 has been spent for transmission line and substation equipment to carry electric power from the plant into the Company's system.

Westinghouse and Sperry Rand Will Develop Control Systems

Westinghouse Electric Corp. and the Remington Rand Div., Sperry Rand Corp., have announced that they will begin joint development of new and improved automatic control systems using electronic computers. The control systems will be for application to automatic control of customers' processes in industrial, marine, and other applications. The two firms will develop co-operatively an advanced line of process control equipment. Westinghouse will have system responsibility for supplying complete systems including installation and related services. The two firms will also continue their independent research and development.

New Pilot Plant Will Convert Sea Water

A pilot plant to demonstrate a new freezing process for converting sea water to fresh water has been placed in check-out operation near Oxnard, Calif. In its first phase, the pilot plant operated by Rocketdyne, a division of North American Aviation, Inc., will be used to develop performance characteristics of the equipment before a series of tests is begun to demonstrate conversion efficiency. The freezing process to be demonstrated eliminates conventional heat exchangers in all principal sections of the freezing cycle. Incoming sea water is cooled first, then frozen to form crystals of fresh water. The fresh water crystals are then separated from the brine surrounding them, washed, and melted to obtain water for domestic and industrial uses.

Huge Centrifugal Fans Installed in Annealing Plant

Three huge airfoil centrifugal fans have been installed in an open coil annealing plant. Westinghouse Electric Corp. supplied the fans to the Lee Wilson Engineering, Co., Inc., builders of the plant. Each fan has a capacity of 240,000 cubic feet per minute at 3.5-inch static pressure. More than 16 feet high, each fan will operate at 460 rpm at an air temperature of

One of the 109-inch-diameter fan wheels being installed

250 F. In operation, the fans will exhaust products of combustion during the heating cycle and will also serve to cool the opened coils evenly and rapidly during the cooling cycle. The fans are powered by 200-hp motors.

New Companies Formed in Electrical Engineering Fields

A new company, *Data Sensors, Inc.*, Gardena, Calif., has been formed to engage in the research, development, engineering design, and manufacture of electrical, electronic, and electromechanical instruments used in the acquisition, conditioning, and interpretation of data for military, space, and industrial programs . . . Hewlett-Packard Co. has announced the formation of a new affiliated company to engage in solid-state research and development. The new firm, known as *HP Associates*, is headquartered in Palo

(*Continued on page 35A*)

Exterior of Charles P. Crane Steam-Electric Generating Station. Construction work shown is for second 191,000-kw unit scheduled for completion in 1963

INDUSTRIAL NOTES

(Continued from page 30A)

Alto . . . Formation of a new company to design, develop, and produce equipment for the digital field has been announced. *Electroplex Inc.*, Los Angeles, Calif., will offer special design, development, and fabrication capabilities and plans development of a product line . . . Starting motors, generators and ignition systems will be manufactured by a new company formed by The Electric Autolite Co., Productos Para Industrias, and a group of Mexican investors. The new firm will be known as *Industria Electrica Automotriz*, S. A. Products manufactured by the firm will be marketed under the Prestolite trade name but the company will also manufacture private label parts in the Mexico City area.

New Mergers, Acquisitions Highlight the Industrial Scene

Gulton Industries, Inc., of Metuchen, N. J., has acquired for a sum in excess of $500,000 in cash the capital of the *Mervyn Sound and Vision Co., Ltd.*, of St. John's, Woking, Surrey, a British scientific research and manufacturing organization. . . . The Boards of Directors of *Public Service Co. of Colorado and Colorado Central Power Co.*, have approved an agreement and plan of merger of the two companies. The surviving company would be *Public Service Company of Colorado . . . Burnell and Co., Inc.*, of Pelham, N. Y., has acquired 80 per cent of the common stock of *GLP Electronics, Inc*, of Bristol, Conn., manufacturer of tantalum and aluminum-foil capacitors.

New Contract Awards Show a Variety of Interests

Equipment to modernize the major portions of the Federal Aviation Agency's telecommunications network primarily in Alaska, has been ordered under a $1,573,646 contract with the *Teletype Corp.*, Skokie, Ill. The contract calls for 200 high-speed teletypewriters and associated telecommunications equipment . . . *Consolidated Electrodynamics/Bell and Howell* has received a contract from *Special Metals, Inc.*, New Hartford, N. Y., for a vacuum arc furnace with design features that make it the first installation of its kind in America. Total cost of construction and installation will be about $500,000 . . . *LFE Electronics*, a division of Laboratory for Electronics, Inc., has been awarded two new contracts by the U. S. Air Force, totalling about $1.8 million for production of ground support equipment for flight line checkout of the AN/APN-131 self-contained, air-borne Doppler navigation systems.

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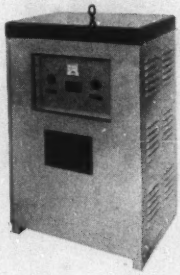
INDUSTRIAL POWER SUPPLIES

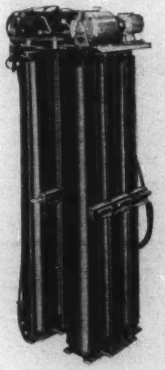
HERE'S HOW... with a GLENN PACIFIC power supply, you can convert your existing single, two or three-phase ac line power into:

- Any desired voltage—fixed or continuously variable.
- AC or dc output.
- Any volt-ampere curve characteristic—constant current, constant voltage, or reactive to any degree you want.



LINE COMPENSATION VOLTAGE REGULATOR for radar station accepts 3-phase, 208v ±10%, delivers 3-phase 208v ±1% at 300 amp., with non-distorted sine wave at all settings. Rated at 108 kw, 100% duty cycle, convection cooled.

ELECTROLYTIC CAPACITOR FORMING power supply provides continuously-variable dc output from 0 to 415 volts, 300 amperes. Input is 230/460 v 3 phase. Other units available with 0-250 v output. Many of these GLENN PACIFIC units are used by leading capacitor manufacturers.



VARIABLE VOLTAGE transformer used in laboratory power supply delivers 0 to 460 v ac at 200 amperes; operates from 3 phase 208/230 v input.

WHAT'S YOUR PROBLEM? Need a dc source for motor drive and speed control—for powering laboratory or production line dc magnets, instruments, test stands—for electroplating, electrolytic refining, etching, de-tinning? You'll be hours and dollars ahead to contact GLENN PACIFIC; please address Dept. 135.

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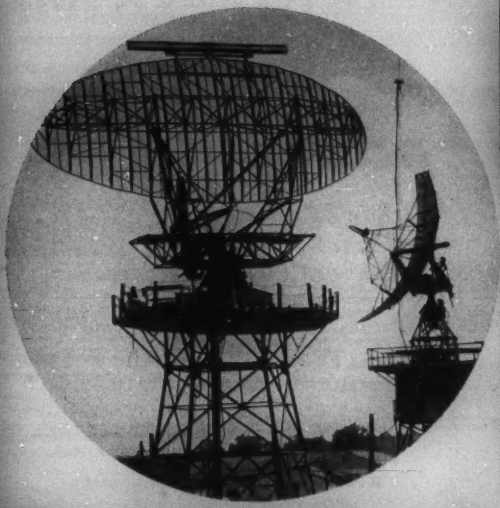
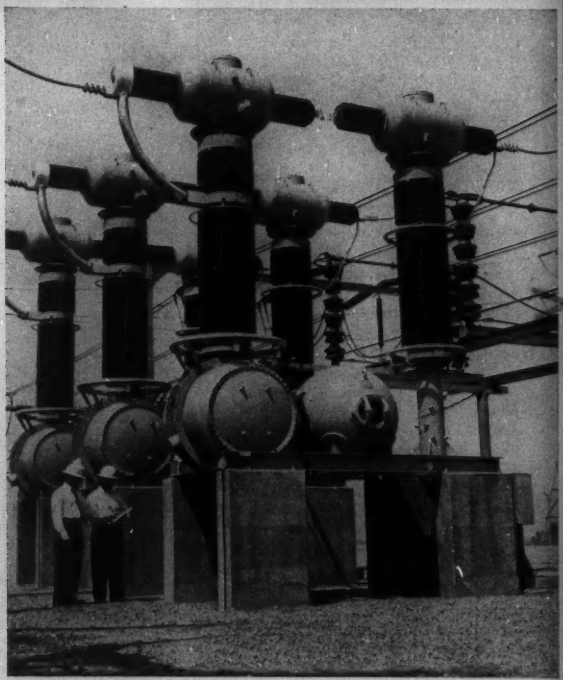
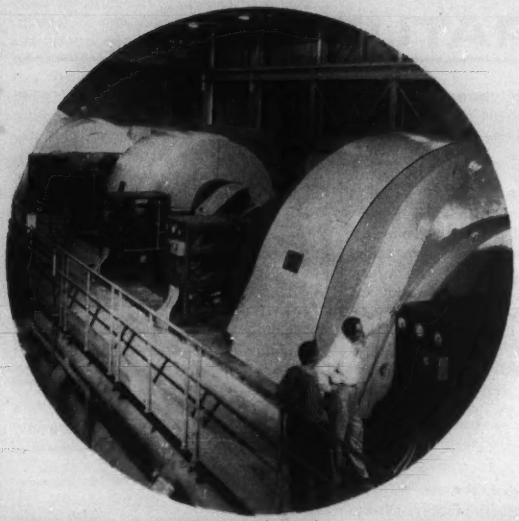


ELECTRICAL ENGINE





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For advance information regarding the *Electrical Engineering Exposition*, write: Reber-Friel Company, Exposition Management, 117 South 17th Street, Philadelphia, Pa.

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PRODUCT LITERATURE

Resistors . . .
A data sheet describing metallic oxide resistors cites new performance guarantees for moisture resistance, temperature coefficient, short time overload, and low temperature exposure. Bulletin CE-2.00 should be requested under a letterhead from *Corning Electronic Components, Corning Glass Works, Bradford, Pa.*

Ferrite Devices . . .
A new catalog lists the mechanical and electrical characteristics of a variety of ferrite devices, including a dc-block, tee circulators, and waveguide and coaxial isolators. The catalog contains model numbers, frequencies, isolation, and insertion loss, VSWR, power levels, dimensions, and prices of more than 50 ferrite units. Copies of the catalog are available from *Sylvania Electric Products, Inc., 1100 Main St., Buffalo 9, N. Y.*

Teaching Machines . . .
"Can Teaching Machines Teach Salesmen?" is a 42-page booklet designed to give sales executives an idea of programmed learning as it can be applied to sales training. The booklet presents the subject as a teaching machine would, a frame at a time, and can be completed in about five minutes. *Porter Henry & Co., Inc., 342 Madison Ave., New York 17, N. Y.*

Closed Circuit TV . . .
Applications of closed-circuit television in science and industry are described in this pamphlet. Some uses outlined are surveillance, transportation and dispatching, security, observation of hazardous locations, and education. Also described is a miniature TV camera, able to observe the interior of a 3-inch pipe. The booklet is available from the *Director of Marketing, Electronics Div., Fairbanks, Morse & Co., 100 Electra Lane, Yonkers, N. Y.*

Measurement Instruments . . .
Bulletin GEA-6788A, 12 pages, describes aircraft electrical measurement instruments. Information on a-c and d-c instruments, aircraft current transformers, and ground maintenance equipment is included, as is data on specifications, weight, mounting, accuracy, connections, shielding, and calibration. *General Electric Co., Schenectady 5, N. Y.*

Differential Transformers . . .
A new 12-page bulletin contains the theory and application of linear variable differential transformers for measuring linear displacements, along with pricing, engineering, and installation instructions. Military specifications and special differential transformer characteristics are tabulated. Bulletin 6208 can be obtained from *Automatic Timing & Controls, Inc., King of Prussia, Pa.*

Spectrum Handbook . . .
"Spectrum Analyzer Techniques Handbook" is the title of this booklet offering detailed measurement techniques using the spectrum analyzer, along with a history and general theory of operation of these instruments. A portion of the handbook describes and lists the specifications and application of analyzers currently available, including the transistorized models. Copies are available from *Polarad Electronic Corp., 43-20 34th St., Long Island City 1, N. Y.*

Strain Recording . . .
A 20-page, illustrated booklet entitled "Strain Recording with Brush Direct Writing Recorders" describes the application of strain gages and strain gage based transducers for accurately recording strain, tension, thrust, load, torque, etc. Basic strain recording circuits are shown for recording from one, two, or four active gages, and techniques used to obtain precise recording of both static and dynamic strain phenomena are explained. *Brush Instruments, 37th and Perkins, Cleveland 14, Ohio.*

Assembly Method . . .
Expansion fitting as a time saving assembly procedure is explained in a twelve-page booklet. It contains a full case history, along with photographs illustrating expansion fitting bearing raceways, and tables of expansion coefficients and nomograms for calculating rates of thermal expansion and determining the temperatures required. *Public Relations Dept., Cincinnati Sub-Zero Products, 3920 Reading Rd., Cincinnati 29, Ohio.*

Light Metals Data . . .
Design data on characteristics and properties of light metals, including magnesium, aluminum, and titanium, are given in this 44-page publication. The booklet lists comparative values for various metals to assist in the selection of materials. The information is presented in tabular and graphic form, and sections are included on alloys. Copies are available from *Brooks & Perkins, Inc., 1950 W. Fort St., Detroit 16, Mich.*

Paint Survey . . .
This booklet offers the operators and maintenance personnel of power generating plants a guide to the selection and use of proper protective coatings on their equipment and buildings. The first part of the survey is the index, which lists the various surfaces and equipment found in the plant, and the recommended paint system for each. The second part provides details of each of the systems, plus discussion on surface preparation. Also included is a section dealing with color codes for power house piping, which has been adapted from the American Standards Association basic guide for pipe identification. *Tropical Paint Co., Cleveland 2, Ohio.*

Transistors . . .
Transistor product data sheets give information on developments in the semiconductor industry. Each of the nine data sheets gives environmental tests, mechanical data, maximum ratings, and other characteristics of the transistors. Copies are free from *Texas Instruments, Inc., P. O. Box 5012, Dallas 22, Texas.*

Flow Charts . . .
A set of 4 flow charts covering the processes used in the electronic industry for the production of printed circuits indicate he operations used to produce printed circuits by the etched circuit process, the solder plated circuit process, the photo resist process, and the plated circuit process. Copies can be obtained without charge from *London Chemical Co., Inc., Dept. EE-2, 1533 No. 31st Ave., Melrose Park, Ill.*

Oscillators . . .
A 4-page booklet, "How to Specify Crystal Controlled Oscillators," contains the requirements necessary to specify these oscillators. Included is a list of requirements for specifying oscillators as well as a selector chart listing the specifications of many oscillators in frequency ranges from 25 cps to 20 mc. Copies are free on request from *Monitor Products Co., Inc., 815 Fremont Ave., South Pasadena, Calif.*

Instrument Glass . . .
A 4-page folder describes arsenic trisulfide glass, a non-toxic, non-corrosive, homogeneous glass now used in sophisticated infrared instrumentation. The folder describes the glass' optical, chemical, physical and thermal properties, and gives typical transmission and refraction indexes. Copies may be obtained from *Servo Corp. of America, 111 New South Rd., Hicksville, L. I., N. Y.*

Electronic Cooling . . .
A 48-page catalog gives mechanical and electrical characteristics of a series of electronic cooling equipment, with performance curves and engineering drawings. A section is devoted to basic design information for ventilating electronic equipment using forced-air cooling. Mathematical formulas and graphs are pro-

vided for problems of cooling solid state circuitry or tube assemblies. Maintenance and service information supplement this section. *McLean Engineering Labs., P. O. Box 226, Princeton, N. J.*

Packaging . . .
A microminiature semiconductor package made of glass that is opaque to visible and infrared light is described in this 2-page bulletin. The bulletin also discusses briefly a method of hermetically sealing the package. Requests should be made under company letterhead, and addressed to the *Receiver Bulb Sales Department, Corning Glass Works, Corning, N. Y.*

Filtration Equipment . . .
Case histories in this publication show that maintenance of clean coolant helps eliminate metalworking production problems, such as shorter tool and wheel life, down time for wheel dressing, tool sharpening, and sump tank cleaning. In some cases, 25 to 50 per cent savings in grinding wheels, honing stones, etc., are reported. Write on company letterhead to *Filtration Division, Hoffman Industries, Inc., Thompson Rd., Syracuse 6, N. Y.*

Conduit Brochure . . .
This 8-page brochure gives information on installation procedures, physical characteristics, and mechanical data of PVC-coated conduit. Shown and described are lighting fixtures and condulets available. The brochure also lists concentrations and temperatures of various chemicals to which the plastic coating is resistant. *Pittsburgh Standard Conduit Co., General Office, Verona, Pa.*

Lighting Transformers . . .
Outdoor lighting transformers and their applications are described in a series of four bulletins. The series includes brochures on mercury-vapor lamp transformers and a bulletin on transformers for use in series circuit incandescent lighting. The brochures contain wiring diagrams and physical and electrical specifications for transformers, including constant wattage and series circuit types. *Jefferson Electric Co., Bellwood, Ill.*

Electric Gaging . . .
"Advanced Trends in Electric Gaging" is the title of an 8-page booklet explaining the function of electric indicator and control units, and describing the typical applications of electric gaging to reduce cost of parts fabrication and inspection. Diagrams accompany the text explaining several applications. Copies may be obtained free from *Industrial Products Div., Hamilton Watch Co., Lancaster, Pa.*

Electrical Catalog . . .
Catalog no. 61 covers a line of electrical and lubricating devices. The products are illustrated, and such engineering data

(*Continued on page 50A*)

Control and Instrumentation Engineers

A key research and development program is now underway at Atomics International to design long-life, compact, lightweight nuclear reactors that will provide auxiliary power systems for space applications. Many interesting problems exist to challenge electrical engineers who want to relate their present experience to reactor technology in any of the following areas:

FLIGHT INSTRUMENTATION DESIGN
Electrical control system design and/or aircraft or missile flight instrumentation design. Will establish flight instrumentation requirements, block diagrams for flight and test systems, preliminary specifications for each instrument or subsystem.

TELEMETRY
Responsible engineers to analyze, plan and specify the telemetry required to ascertain the performance of nuclear power plants during space tests. The individuals must have experience in missile instrumentation and telemetry of temperature, vibration, acceleration, etc. BS or MSEE preferred.

CONTROL ANALYSIS
Dynamic and control analysis including system start-up and full power operation. BS or MSEE plus familiarity with latest analog and digital techniques required.

CIRCUIT DESIGN
Electronics engineers experienced with both vacuum tube and magnetic devices to design and develop control circuits for compact nuclear power plants.

All qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin.

For specific details write: Mr. E. L. Newton, Personnel Office, Atomics International, 8900 DeSoto Avenue, Canoga Park, California.

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SITUATION WANTED advertisements for AIEE members are published at special rate of $2.00 per line, minimum charge 5 lines.

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INSTRUCTORS, Associates, Assistants for teaching and research part-time position while working for M.S. and D.Sc. Large graduate program assures variety of offerings. Chairman, Electrical Engineering Department, University of New Mexico, Albuquerque, New Mexico.

TRANSFORMER ENGINEER. With experience in the design and development of Hi-Frequency and Pulse Transformers for commercial and military applications. Ideal opportunity for ambitious man to develop full potential of present small department. Salary—open. Location—Erie, Penna. Call or send resume to: Chief Engineer, Erie Electronics Division, Erie Resistor Corporation, 645 West 12th Street, Erie, Penna., GL 6-8592.

PRODUCT SALES MANAGER. To supervise O.E.M. accounts. Top opportunity with growing firm for E.E. graduate with strong design background or experience in applying transformers to motor, control, and power supply problems. Write Jerry Frank, Hevi-Duty Electric Company, 3002 West Burliegh, Milwaukee, Wisconsin, UPtown 1-9100.

TRANSMISSION ENGINEER—Graduate engineer with a minimum of five years experience in design of electrical transmission and substations. Knowledge of carrier and supervisory desirable. Excellent opportunity for advancement in a rapidly expanding organization in the southwest. Liberal fringe benefits. Submit resume, including education, experience, personal qualifications and salary requirements to Box No. 157.

RELAY TECHNICIAN—With a minimum of five years experience in protective relay work including test, calibration and maintenance. Knowledge of carrier and supervisory desirable. Excellent opportunity for advancement in a rapidly expanding organization in the southwest. Liberal fringe benefits. Send resume, including education, experience, personal qualifications and salary requirements to Box No. 158.

INFORMATION CENTER ENGINEER. Originate, maintain technical information center for twenty-man engineering staff use. Should be able to: index according to modern information retrieval & dissemination systems; read in depth with speed; abstract technical articles, reports; type. Prefer female with B. S. degree. Salary—open. Progressive 450-employee company in scenic, suburban Hudson Valley. Write or call Peter W. Rakov, Rotron Manufacturing Co., Inc., 7 Hasbrouck Lane, Woodstock, New York. Area Code 914-OR 9-2401.

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New Bourns Precision Potentiometer Resolves the Quality-Price Dilemma!

NUMBER 18—NEW PRODUCT SERIES

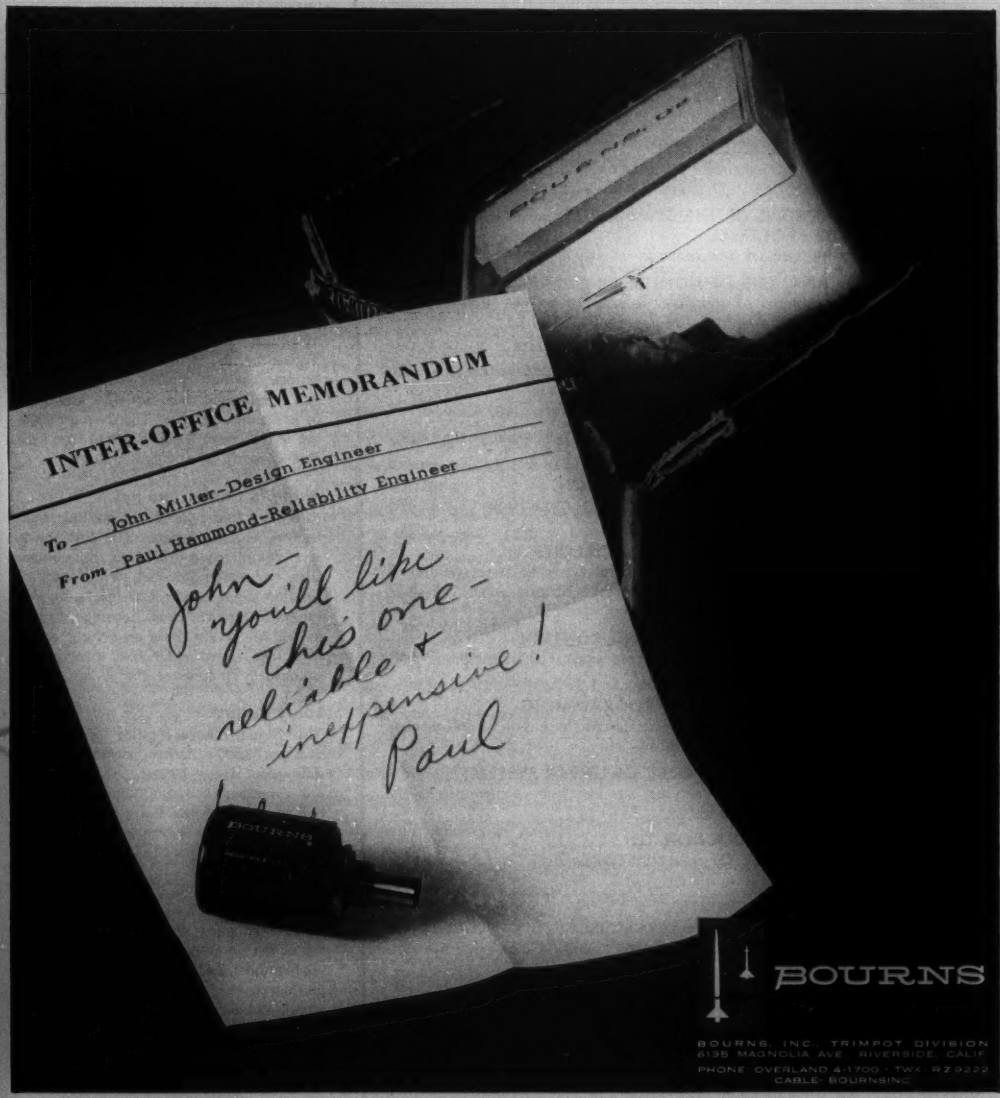
Here is military reliability in a competitively-priced industrial potentiometer. Bourns wirewound 10-turn Model 3500 measures just ⅞" in diameter by 1" long—shorter by ½" than units available elsewhere—yet has a resistance element 20% longer than that of comparable potentiometers.

Fully meeting military requirements for steady-state humidity, Model 3500 can also be provided at a 10% premium to meet the cycling humidity specs of MIL-STD-202, Method 106. It's the only ⅞" 10-turn potentiometer guaranteed to meet this spec. Its published characteristics incorporate wide safety margins.

Reliability insurance is provided by the exclusive Bourns Silver-weld® bond between terminal and resistance wire. Virtually indestructible under thermal or mechanical stress, this termination eliminates a chief cause of potentiometer failure. In addition, a special close-tolerance rotor almost completely does away with backlash.

Model 3500 is also subjected to the rigorous double-check of Bourns' exclusive Reliability Assurance Program. In short, every possible step is taken to ensure that the performance you specify is the performance you get. Write for complete data.

Resistances	500Ω to 125K, ±3%, std. (to 250K spl.)
Linearity	±0.25% std.
Power rating	2w at 70°C
Operating temp.	−65° to +125°C
Mech. life	2,000,000 shaft revolutions



Manufacturer: Trimpot® potentiometers; transducers for position, pressure, acceleration. Plants: Riverside, California; Ames, Iowa; and Toronto, Canada

Wiley BOOKS

HANDBOOK OF AUTOMATION, COMPUTATION, AND CONTROL
Vol. 3: Systems and Components
Edited by E. M. GRABBE, S. RAMO, and D. E. WOOLDRIDGE, Thompson Ramo Wooldrige Inc. The modern approach to systems engineering, describing control components and how they combine to form complete systems. Typical systems are automatic machines, process instrumentation, process control, flight and fire control, and the like. 1961. Approx. 1208 pages. $19.75. ALSO—Vol. 1: Control Fundamentals. 1020 pages. $18.50 Vol. 2: Computers and Data Processing. 1093 pages. $1850.

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(*Continued from page 39A*)

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Bulletin EI-65A describes a heavy duty electrical insulation material, illustrates methods of applying it, and contains a table of properties for the material. It is coded for AIA filing. Copies are available from *Johns-Manville, 22 E. 40 St., New York 16, N. Y.*

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This catalog gives characteristics of transistors made from germanium and silicon, as well as rectifiers, diodes and capacitors. Tables on the products give maximum ratings, current transfer ratio, saturation and small-signal characteristics, and other ordering information. The 24-page catalog is free from *Texas Instruments, Inc., P. O. Box 5012, Dallas 22, Texas.*

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